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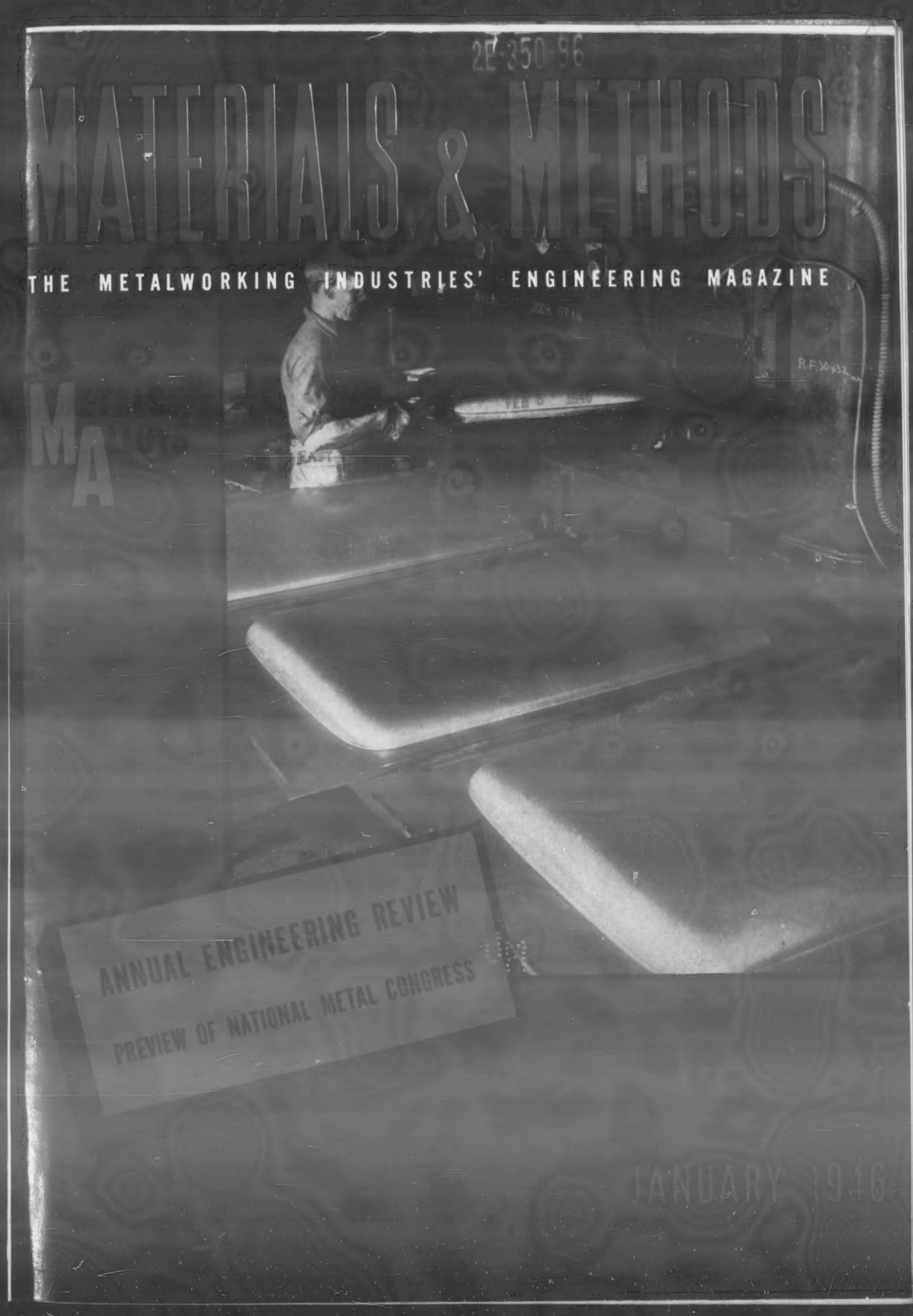
MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE



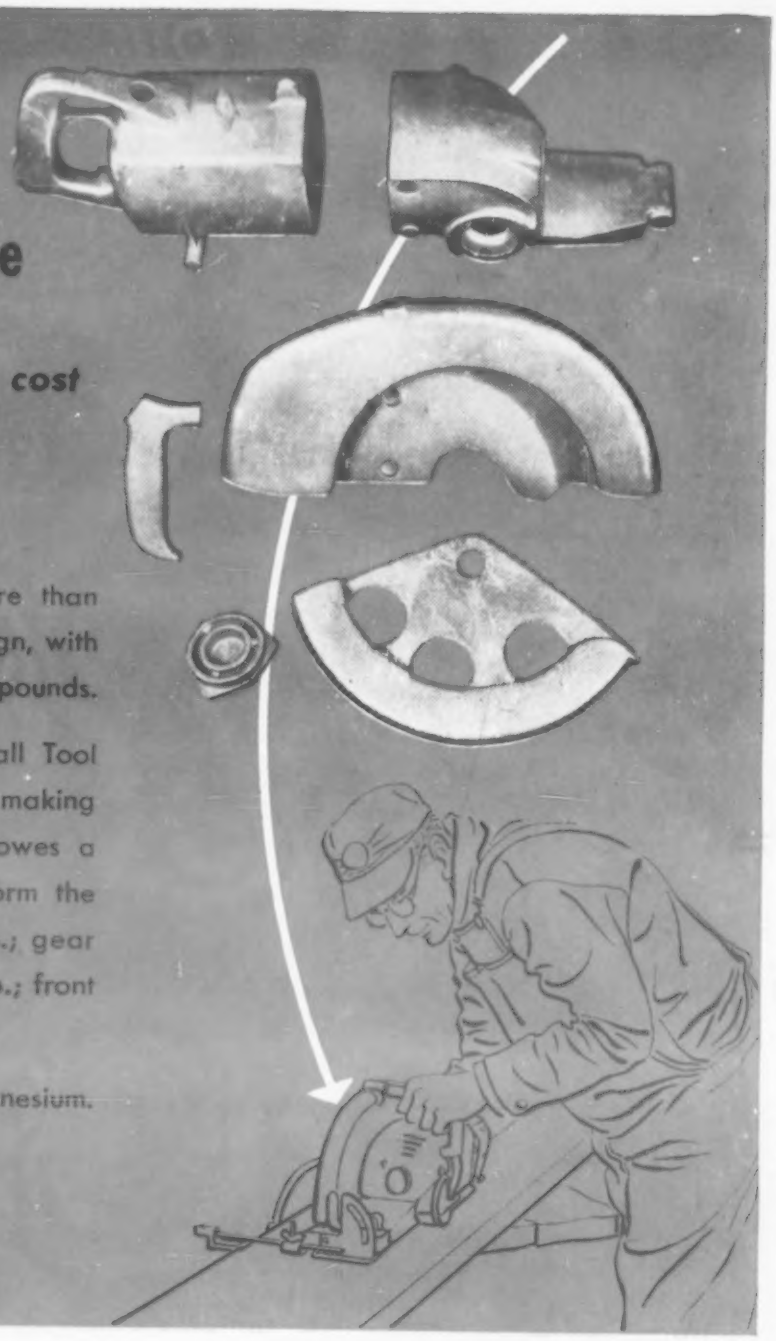
ANNUAL ENGINEERING REVIEW

PREVIEW OF NATIONAL METAL CONGRESS

JANUARY 1946

Where lightness cuts . . . fatigue

cuts time . . . cuts labor . . . cuts cost



Here's a sturdy portable power saw built to cut more than lumber! It's cutting *expenses* on many a job. Skillful design, with *lightweight magnesium*, has held its weight down to 36 pounds.

This product is regarded by its manufacturer, The Mall Tool Company, as the most powerful saw of its type for making heavy cuts. Its combination of lightness and strength owes a great deal to the durable magnesium castings that form the motor housing and back handle, weighing only 2½ lbs.; gear housing, 3½ lbs.; upper guard, 2 lbs.; lower guard, 1 lb.; front handle, ¼ lb.; and bearing cap, ⅓ lb.

It's one of many fine new products making use of magnesium. For further information, contact the nearest Dow office.

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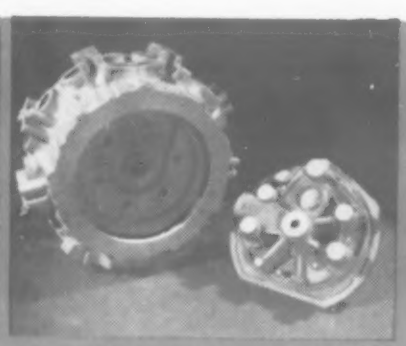

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MATERIALS & METHODS

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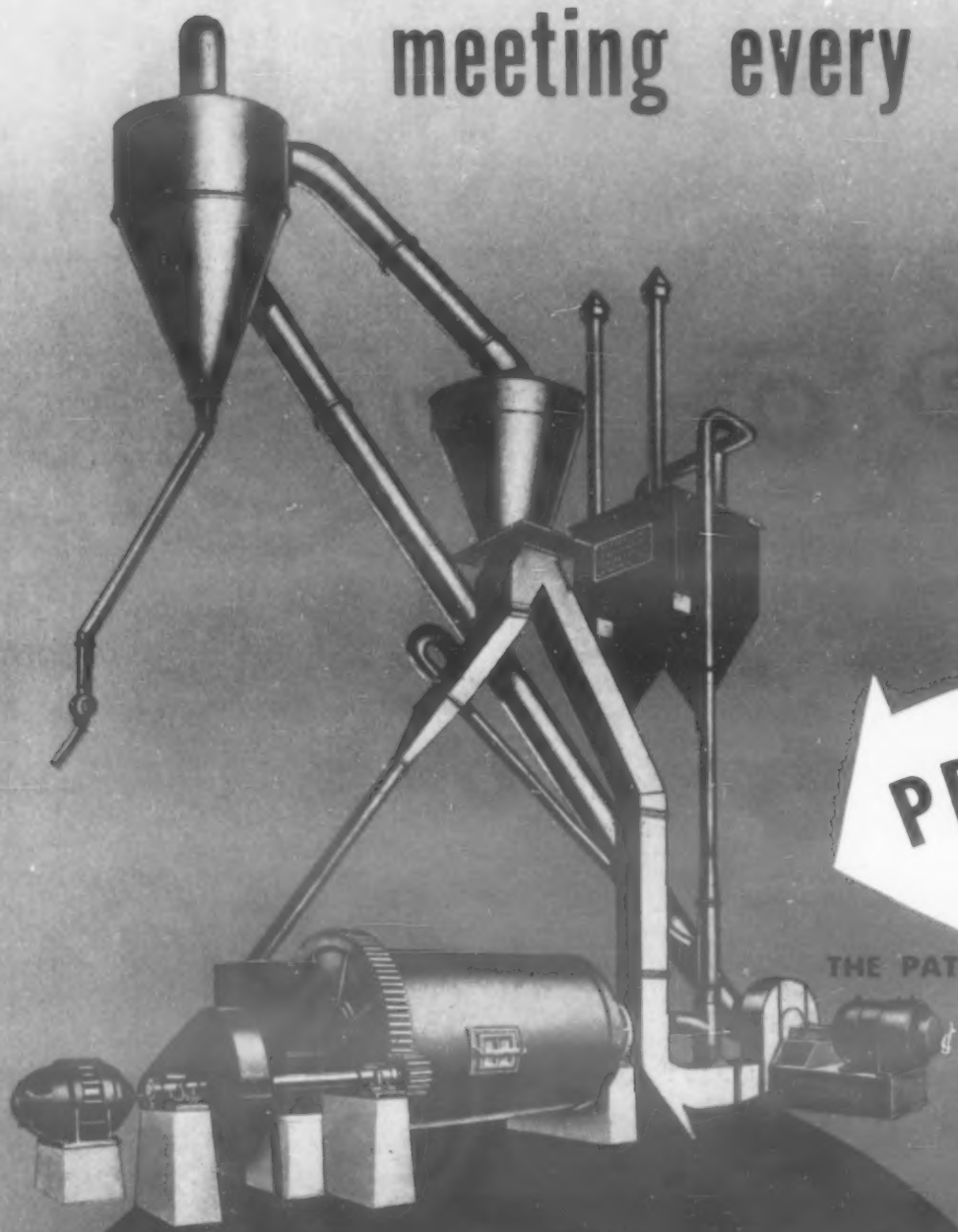
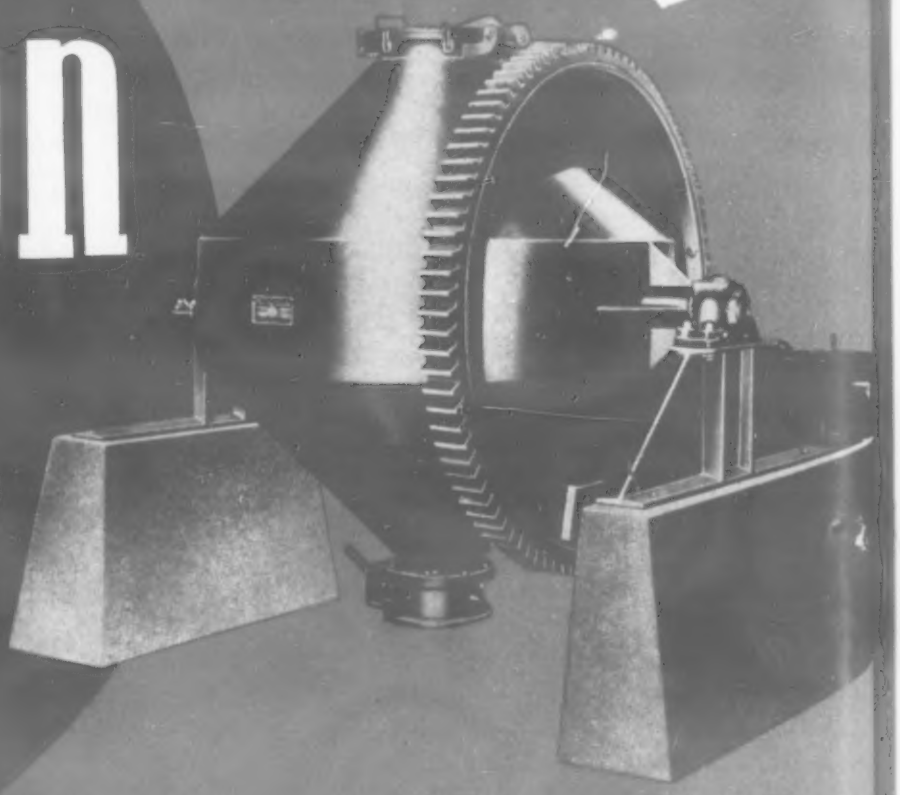


THE PATTERSON CLOSED CIRCUIT GRINDING SYSTEM

THE PATTERSON CONICAL DRY BLENDER



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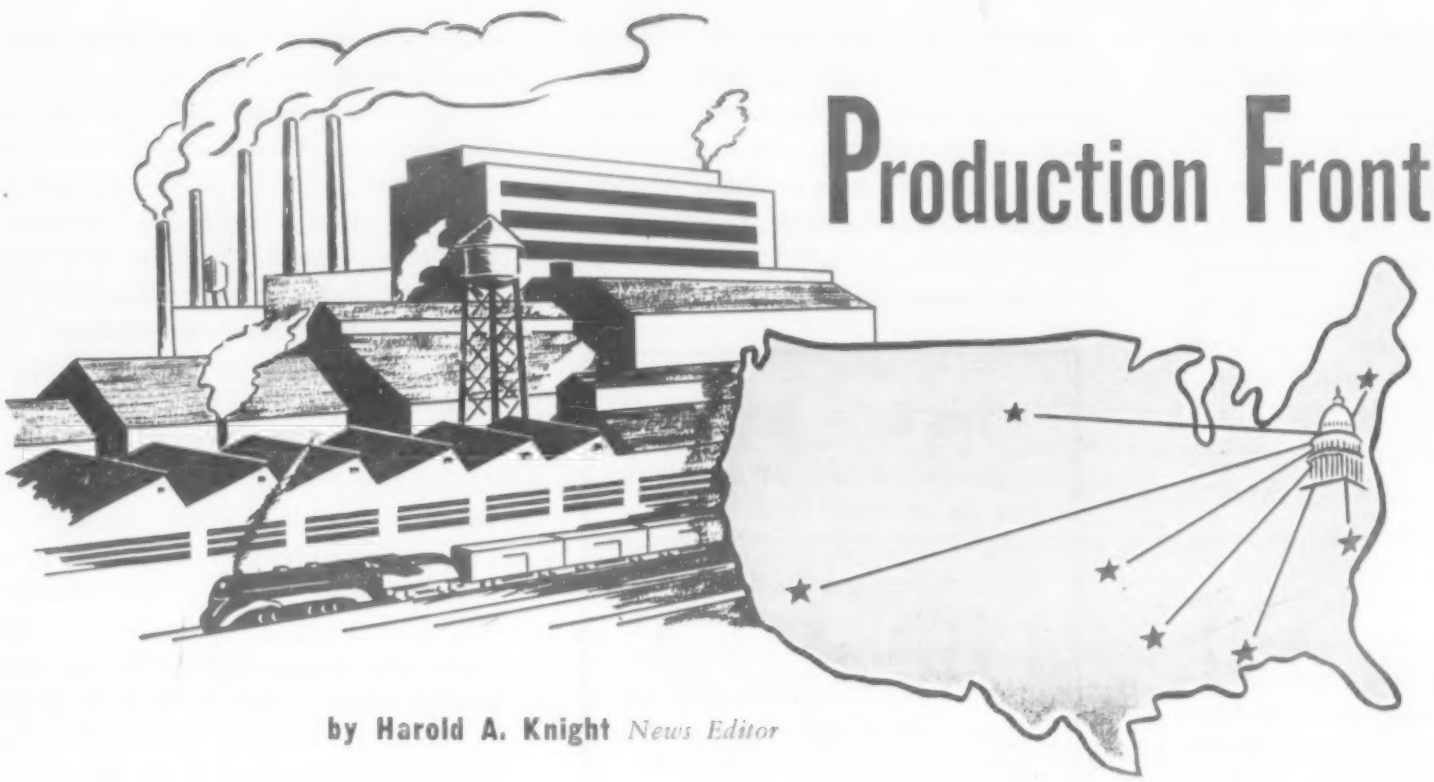

Production Frontiers

by Harold A. Knight *News Editor*

Madame Curie's father described radium as "only of theoretical interest" . . . Two more "heavy elements" besides neptunium and plutonium . . . So far they are only numbers, 95 and 96 . . . Do you have an atom sorter in your home? . . . Fortunately, Westinghouse had a supply of pure uranium . . . Germans lacked cobalt and columbium for jet propulsion . . . Electronic corn popper—so what? . . . We try to avoid "Press" tables.

Ethyl alcohol and liquid oxygen fueled the V-2 rocket . . . But the turbine is driven by hydrogen peroxide and sodium permanganate . . . Compressed nitrogen forces the fuels . . . Alcohol also serves as coolant . . . Rockets started with black powder torch . . . Early rockets had radios, controlled from ground; later controls were self-contained . . . Flight time, 5 min.; peak acceleration, 8 g. . . . With a booster (a second plane that would not reach destination) a range of 1500 to 3000 miles is theoretically possible.

Our cartoonist meditates on stainless steel stockings . . . Metals that go into television sets are thoroughbreds . . . A technical G. I. inspects a Jap aluminum tubing mill . . . When experimenting with radar at Atlantic Highlands, N. J. they scrutinized gasoline tanks on Empire State Bldg.

Atom Bomb: "Truth is Stranger than Fiction"

Interesting new details involving our manufacture of the atomic bomb will be coming out for many months yet. The world may not recover for a long time from the shock and perhaps dread which impinged on that fateful day over Hiroshima. One recalls that when Madame Curie's father congratulated her on the discovery of radium he remarked: "What a pity it is that this work has only theoretical interest." It again proves how what is once regarded as "pure science" is finally harnessed to serve man practically.

One has heard much about the discovery and manufacture of two new elements, neptunium and plutonium, during the development of nuclear fission. Two other new man-made elements were also developed at the same time, perhaps less widely known. These are known so far only by their atomic numbers, 95 and 96. They were produced by bombardment of uranium and plutonium in a cyclotron.

Only submicroscopic quantities are as yet available, but adequate for scientific investigation. They are radioactive, but it is not revealed whether they disintegrate with release of energy. Thus, a still further step has been taken since Becquerel's discovery of radioactivity in 1896. There are now six "heavy elements" on which the nuclear scientists are focusing attention.

Machine That Sorted Atoms

A very important gadget in the manufacture of the atomic bomb was an electrical sorting machine that hurls invisible atoms into a vacuum chamber and groups them according to weight. The machine, a Westinghouse creation called the "Calutron," helped isolate Uranium 235. The device detects the scarce 235, which appears in natural uranium in a ratio of 1 to 140, and deposits it in traps.

Uranium is introduced into the machine in volatile form and strikes an arc of electricity, discharged in a vacuum. This breaks it down into atoms and tags each atom with an electrical charge. A magnetic field in the tank causes the ionized uranium atoms to move in circular paths.

The 235 atoms, slightly lighter than other atoms of uranium, move in a slightly smaller radius and are trapped in separate receiver boxes. Of course, it is not as simple as writing this description on paper. The magnetic field must be exceedingly well regulated, and there must be very little ripple in the high voltage supplies; otherwise, the ion beams will wander —fail to be collected or move into the wrong receiver box.

Another important contribution to the bomb project—and one might say almost an accident—was a ready supply of pure uranium already collected when "time was of the essence." Dr. Harvey Rentschler, a Westinghouse scientist, had been producing pure uranium in small lots for many years. He started accumulating it shortly after World War I when in search of a material superior to tungsten for lamp filaments. By the end of 1942

Westinghouse had boosted production to 100 lb. daily. "Pure science" had crashed through again!

Germans Lacked High Temperature Alloys

Our metallurgists continue to come back from Germany with interesting tales. Failure of German air power late in the war was due in no small measure to lack of any outstanding super-alloy steels and the shortage of such vital alloying elements as cobalt, states A. L. Feild, director of research, Rustless Iron & Steel Corp.

German special steels for jet engines did not approach the high temperature alloys in the U. S. for jet plane blading material. Shortages of cobalt and columbium had to be offset by the Germans through extremely clever design of the jet engines. They had to develop grades of steel and alloys where molybdenum, nickel and columbium were either not used, or were largely replaced by manganese, titanium and vanadium.

To close on a whimsical note, we see they have developed electronic popcorn poppers. Great Day! We earned our first bicycle by selling: "Popcorn—5 a bag—popped in the kettle in the old-fashioned way." We can see our dear old grandmother yet—standing over the old wood-burning cook stove, adding a spoonful of lard to the kettle, shaking the daylights out of the kettle as the corn started poppin'. Good old granny! And even better—popcorn!

Rocket Plane: N. Y. to London

Perhaps the most spectacular development in the late war was the V-2 German rocket, 46 ft. long, 5 ft. 5.3 in. in body diameter, which climbed 60 or 70 miles, had a speed of 3,400 m.p.h. and a range of 220 miles. It was a contraption that somewhat crudely typified Buck Rogers and would have made Jules Verne dance with excitement.

Some interesting little known facts about this monster of the skies was recently told by the British aeronautical scientist, W.G.A. Perring, under auspices of the Royal Aeronautical Society. The rocket was the product of the German scientist, Prof. V. von Braun, who compares the stage of development with that reached by the airplane in World War I.

The first V-2 was fired July 6, 1942, rose 3 ft. from the ground and exploded, destroying the testing station. The second rose 16,000 ft. and exploded, as did the third. The fourth and fifth flew satisfactorily. Then came 13 failures. Some failed to fly, some broke in two, others exploded. Then over 100 were fired and, though improvement was noted, failures were 15 to 20%.

The warhead, 5 ft. 11 in. long, occupies the nose; immediately behind are the main control instruments and radio or other control equipment. Large hinged panels on the shell provide servicing access to the instruments. The main fuels are in two large light alloy tanks in the central compartment of the rocket. In the forward fuel tank is 75% ethyl alcohol in water; in the rear tank, liquid oxygen.

Remaining space is taken up by the turbine, which drives the two main fuel pumps; the auxiliary fuel supply; main combustion chamber and exit venturi. Around this unit are the stabilizing fins, while projecting into the exit of the venturi are the main control vanes. The rocket structure is built up of steel ribs and stringers, covered by thin steel sheets.

The thrust of the jet is transmitted from the venturi unit through a heavy tubular steel framework, to a circular angle frame at the forward end of the power compartment, the frame also supporting the turbine and pumps. The warhead shell is steel, 0.25 in. thick—not protected from conditions experienced by the outer skin of the rocket during flight.

The turbine is driven by a hydrogen peroxide—permanganate system, the liquid oxygen and alcohol being the main fuels. Hydrogen peroxide in one tank and sodium permanganate in another are fed by compressed nitrogen to a burner. Pressure in the alcohol tank is first achieved by ram pressure, but later pressure is supplied by nitrogen. Liquid oxygen is fed to 18 brass roses in the combustion chamber, while the alcohol is pumped to an annular ring at the rear end of the venturi.

The venturi is of heavy welded mild steel, a large portion being jacketed to accommodate the alcohol coolant. After serving as coolant, the alcohol mixes with the oxygen and burns. Gas temperatures in the combustion chamber reach 4900 F.

The velocity of discharged gases is 7000 ft. per sec., with 275 lb of fuel burned every sec. The thrust developed is 60,000 lb. When firing, the rocket is vertical and is usually started with a pyrotechnic (black powder) torch. From torch application to fuel thrust of the rocket takes 7 to 10 sec. After flying straight up, the rocket tips to 45 deg. to the horizontal (after 60 sec.), the tipping being done by eight controllers—four graphite controllers around the jet exit and four at the tips of the stabilizing fins. Other controls are in the form of gyros that regulate pitch, yaw, rotation, etc., with electronic devices having a part.

Earlier models contained two radio sets, controlled from the ground, and with guards against false signals. Later, an integrating accelerometer

Face Red?—Well, Pink

All our journalistic life we've had an aversion to sitting at a table marked "Press." It sets us off as different from the others. It implies we do not belong, nor have the price of the meal. A psychiatrist explains that we are secretly itching to sit at the speaker's table. Be a big shot.

The other day we were invited by B. B. Caddle, Copper & Brass Research Assn., to a luncheon of the Trade Association Executives in New York City. The speaker was Dr. Leo Wolman, professor of economics, Columbia University, on "What's Ahead in Labor-Management Relations?"

Now, Doc Wolman calls his shots high, wide and handsome. He explodes old economic dogmas with the force of nuclear fission disintegration. Questions followed from the audience. One was: "Does the press understand and interpret correctly the labor-management fracas?"

Whereas the good doctor had previously pop-popped, he now bang-banged. The Press is a moron. Hundreds of eyes turned to the Press table, with broad grins. However, all of the writers, but us, had left because of other engagements. Two nonmembers of the press, sitting there by accident, took the brunt of the good natured sarcasm. Our back was turned, so we escaped. But we still don't like Press tables.

was used, making the rocket self-contained. Since the main flight path is parabolic, the height reached was always a quarter of the range. Flight time was 5 min. The highest acceleration is about 8 g.

It is interesting to consider peace applications. One of the late German rockets was a booster—two rockets, one to help in power and then abandon the trip while the second reached its destination. By taking out the warhead of the V-2 and substituting cabin and pilot and adding wings (using no booster), the range could be 350 miles. But with a booster, a range of 1500 to 3000 miles is theoretically possible.

A trip from New York to London would be done in under 1 hr. However, this would mean a flight of 8000 m.p.h. and friction through the air would make the pilot perspire, to put it mildly. The booster would have to weigh about 100 tons and be recoverable — one would hope. Controllers at such speed would probably have to be small rocket jets, as external forces would be too small.

Personally, we prefer somebody other than we take that first experimental rocket ride overseas!

Materials in Television

Selling of home television receiving sets at around $200 to $300 each is just around the corner — come spring or summer. Let's rig up a periscope and look around that corner, with a "materials" and "methods" viewpoint. These receivers will be black and white pictures, 4½ by 6 in., or maybe 6 by 8 in., but with pictures the size of a newspaper page in the offing. Color television is now in the laboratory only, but may emerge in 2 to 5 yr.

In the new black and white sets, eye strain has been eliminated, as has been the annoying grayish overtone. Naturally, war developments in electronics and radar have skyrocketed television technique since the days when television was introduced at the time of the World's Fair in 1939. At first the channel had to be broad, but by now the "microwave" has been developed, confined to infinitely small channels.

Since television waves travel in a straight line and off into space, the range is only 20 to 60 miles, though under ideal conditions 129 miles have been accomplished, such as between New York and Schenectady. But this will be solved by relay stations—where high points are available, 60 and 100 miles apart; otherwise 20 to 30 miles. Thus, television will make use of wires as well as air.

"Inco" (International Nickel Co., Inc.) has interesting things to say about television. Thus, two types of receivers are being planned. One where the image is viewed directly on the cathode ray tube, called the direct method; the second where the image is reflected on a screen, attached to the set, or suspended from the ceiling like a home movie screen, called the projection model.

The heart of television, both in transmitting and receiving, are two cathode ray tubes. Those in the transmitter are "iconoscopes," or perhaps "orthicon" or "dissectitubes," the latter two being to television what the microphone is to radio. In the iconoscope, light passes through camera lenses and the scene is imaged on a screen coated with tiny drops of silver, covered with chemicals to make them tiny photo cells. Each drop becomes electrically charged, depending on light intensity.

An electron beam from a nickel cathode scanning the plate removes each charge, line by line, from the plate in the form of electrical impulses, sent over the air as signals by complicated electrical circuits. The receiver has 16 to over 30 tubes, the largest of which is the cathode ray tube, corresponding to the loud speaker in radio. Its inside face is covered with fluorescent materials. A coated nickel cathode in this tube produces electrons, or tiny particles of negative electricity, whose number depends on the strength of the broadcast signal as received.

These electrons are attracted by positively charged electrodes and, ac-

STRESS RELIEF By GILBERT

REPAIRS

[*News item: Stainless steel stockings are a post-war probability—American Iron & Steel Institute*]

quiring tremendous velocity, are fired as a stream against the screen by an electron "gun." Deflection plates or magnetic sweep coils deflect the stream up or down, right or left. Delicate sweep circuits apply the correct voltage to these plates or current to this circuit, causing the electron stream to sweep over the fluorescent coating of the cathode, the coating converting energy into light.

The light forms images by closely spaced lines (525 lines for the entire picture repeated 30 times a sec.), so swift that the human eye sees smooth-flowing action. In direct view receivers the tube is also the screen. In indirect models a lens throws the image on a screen.

All tubes are made of glass and metal. After sealing and air evacuation, there are still gases in the metal, removed by induction heating to 1850 F. Such metals must have versatile characteristics, such as strength, even in thin sections; soft tempers to avoid deformation by constant handling during manufacture; a high modulus of elasticity through all temperatures; ability to provide strong spot welds and resistance to oxidation during welding and to corrosion later; resistance to warpage and distortion; accurate retention of shape and close clearance of all parts, especially in small tubes.

The metals must have suitable electrical properties, such as proper electron emission; must be low in contained gas and readily susceptible to de-gassing; must be easily formed and fabricated. Some parts must be non-magnetic, such as Inconel and nickel-chromium stainless steels; or of high magnetic permeability, such as Permalloy, particularly for shields external to the tubes. The bulk of cathode ray tubes use a 12% nickel stainless steel. Nickel is standard for receiving cathode tubes and many other internal parts. The vacuum-tight seals between metal and glass use copper-clad nickel iron, cobalt iron nickel, or a low chromium nickel iron.

Drawbenches Have Their Drawbacks

The tube mill in an aluminum plant in Shimonoske, Honshu, Japan, was recently inspected by one of the American occupying troops, Pfc. Chet Campbell, formerly tube mill foreman at the Lafayette, Ind. works of the Aluminum Co. of America. He writes back to the States with a bit of contempt oozing out the point of his pen. Here's his story:

"They have twelve drawbenches about the size of our 30,000-lb. benches, but the funny part about it is, they don't run from individual motors. There is a large shaft that runs the length of their benches and there is a sprocket on the shaft for each bench.

"There is a control back by the draw head where the operator can throw his machine into gear.

"To operate the bench, it is necessary to throw it out of gear after pulling a tube, then pull the carriage back by hand, hook up the carriage and throw it in gear again. They cannot hook the carriage while the chain is in gear. When the chain is running, it only moves about as fast as the chain on our 50,000-lb. benches do before the limit switch is tripped. A rather crude way of making tubing. The only bloom size I saw was about the equivalent of our 2.3 by 0.147. I guess they only have one alloy, as everything is thrown together.

"They use a horizontal heat treat furnace that is electrically heated. I don't see how they get the proper quench on their metal, as they have to lift it out of the furnace and travel about 5 ft. to quench it."

Lesson in Radar—No. 4

The importance, novelty and romance about radar justifies, we hope, this fourth descriptive piece in the past five months. Additional interesting details and anecdotes continue to come out of the secret archives. Westinghouse reveals the following:

Say the radar apparatus is on a ship that is scanning the horizon for hostile submarines or aircraft. A hostile target has shown up on the radar screen and the range in miles has already been read. The operator next wishes to get the relative bearing of the target in respect to the heading of his ship. An electrically-coupled mechanism links the rotating antenna with a calibrated dial and the relative bearing of the ship with the target is read directly. Say the ship is heading northeast at an angle of 45 deg. from true north and a target is located on the scope at 70 deg. from true bearing. Then the relative bearing of the target with respect to the heading of the ship would be 70 deg. minus 45 deg. or 25 deg.

Still another indicator, electro-mechanically connected to one of the cathode ray scopes, enables the radar operator to read the range of a target on a gage. With a fast-approaching plane as target, the operator turns a handwheel in synchronization with the cathode-ray scope and can "track" the plane mile by mile as it nears the detection system. The radar will also give angle of elevation and slant range of the craft, possible because the angle at which the antenna is tilted when the airplane is located exactly duplicates the angle of elevation of the aircraft.

To produce a tube that would generate thousands of watts at tremendous high frequencies, the engineers had to violate nearly every known rule about radio tube design. Production engineers shook their heads sadly. Veteran glass blowers said: "Impossible to make in any quantity." But months later the tube was in mass production, with the doubting Thomases helping to speed output.

The Army ran 40 field tests of the tube and set, conducted behind blinds on a hill near Atlantic Highlands, N. J. Even the armed guards were unaware of the confidential character of the activity. To test the accuracy of the radar set, gasoline tanks at the end of Staten Island and on the Empire State building were used as targets. A radar beam was "squirted" at these targets, whose direct air range was known, and calibrations were made on the basis of their electronic echoes.

Later tests were made at night with big Army searchlights. An airplane pilot performed as many circus maneuvers as he chose, the shutters of the searchlight being closed, while the radar followed his movements, blind to the human eye. Suddenly the searchlight would be turned on to where the radar said the plane was—sure enough, the plane was right there!

There were "phenomena" which fooled the radar operators for a while. During one test a double image appeared on the fluorescent screen—another plane had secretly joined the test plane. The image of another test plane suddenly increased greatly in intensity—the pilot had banked his ship to turn around for the home trip and had presented his plane broadside to the radar. More than a year before Pearl Harbor, radar sets stood guard at the Panama Canal. Sea captains approaching the canal were amazed to see U. S. patrol planes flying out to observe them long before their presence would normally be known.

1945-1946 — A Problem and a Pledge

Nineteen hundred and forty-five will be one of History's milestones. Exactly what the marker will say we cannot yet know: It may record the ending of the world's worst war and the beginning of a period of permanent peace; or it may show that a great war ended simultaneously with the first use of a fearsome weapon, and that some time thereafter the victorious allies proceeded to use that weapon to destroy each other.

Narrowing it down to just America, the legend may show that 1945 marked the sudden end of a false wartime prosperity and the tragic failure of Americans to realize that it was false and that real prosperity comes only with the maximum production of goods and services, at low prices and reasonable wages—not at inflated wages and high prices; or it *can* show that Americans went to work the next year, produced more low-cost goods than ever before and started an era of real prosperity the like of which the world had never seen.

Getting really close to home, we believe that the metalworking industries have learned a lot in four years about the skillful application of engineering materials and about methods for processing them, and that this knowledge can and will be used to offset the higher labor and other costs of making 1946's peacetime products. Down that road also lies maximum production, and your editors hereby reaffirm their wish to make 1946 the happiest year for everyone in the metalworking industries by doing all in our power to see that materials and methods are most wisely applied to those ends.

This is our New Year's pledge to you!

—F. P. P.

Atomic Power for Peacetime Use — When?

Through all the smoke and scarehead stories of world destruction that have come out of the atomic bomb, along with predictions of a push-button world with limitless power, several facts about utilization of atomic energy begin to emerge. First of all, the splitting of uranium or other atoms does not provide us with a new power plant—only with a new fuel. Dr. Sanford A. Moss, consultant to General Electric Corp., speaking before the Air Transport Engineering meeting of S.A.E. in Chicago last December, pointed out that atomic energy is nothing more than extreme heat. A means of harnessing this heat remains to be worked out.

Secondly, sources of available atomic energy are at present too scarce and too costly to be commercially practicable. Uranium and its derivatives are too

See These Three at the Ryerson Exhibit

1. "Clean Cut" Plates. That's their trade-name—"Clean Cut!" A plate that machines just about twice as easily as ordinary steel. Takes a beautiful finish with ordinary machining. Also welds easily and smoothly without special technique. And case hardens readily.

Actual demonstration of the superior machining qualities of "Clean Cut" Plates will be made at the Ryerson Booth. Be sure to see it.

2. Movie of Ryerson Alloy tests. These tests make possible the complete data furnished on every alloy in every Ryerson shipment, including the accurate heat-treating information.

3. Nitralloy—produces the hardest metal surface known when properly heat-treated (nitrided). Samples of nitrided parts made from Nitralloy will be exhibited.

May we have the pleasure of showing you the above three features of the Ryerson Exhibit at the National Metals Congress? Remember the Ryerson Booth is B-134.

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scarce to compete with present-day fuels. Coal, petroleum, and water power are cheap and still readily available, and the techniques and equipment necessary to convert their energy into useful work are well understood.

The present state of affairs, then, is that physics research and engineering have produced a new fuel. The engineer must now produce the power plant to harness it—a task that may well require a decade or more. The gas turbine has been suggested as a possible harnessing mechanism, and it is in many ways the most promising for this purpose. A hint of a possible method of control of the atomic disintegration comes from the reacting pile itself, in which a lattice of boron steel rods can be inserted when and to the extent needed to slow down the chain reaction by absorbing a controlled fraction of the freed neutrons.

The statement was made in the original release of information on the atomic project, the Smyth report, that the principal obstacle to use of atomic energy would be the lack of high-temperature materials. This seems to be borne out by what has been learned since, as well as by results with the gas turbine itself. But recent progress in high-temperature materials has been very great, and further advances are certain in the years just ahead.

As to the scarcity of uranium, this problem may not be as difficult as appears. The basis of liberation of atomic energy has been the creation or separation of atomically unstable material. At a discussion of atomic energy and its possibilities at a Dayton, Ohio, meeting of S.A.E., Dr. Poole, of Ohio State University, pointed out that instead of 92 elements we now have, theoretically, some 320 elements and their isotopes, all potentially available by juggling the intra-atomic building blocks of the universe. There seems to be a strong likelihood that some of these isotopes of more common elements, synthetically prepared and atomically unstable, may be our future sources of atomic energy.

—K. R.

Continued Recognition for the Engineer

Much credit for our war winning flow of armament has gone to manufacturing engineers and executives. However, in our reconversion these important groups are likely to fade out of the limelight and their achievements to be overshadowed—as far as top management and the public are concerned—by the more obvious feats of the sales staff.

This condition should not come about, for the process engineer is destined for an even more important role in peace than in war. Then it was a problem of getting the material out fast, regardless of cost. Now, economic pressure, in the form of labor's demands for higher wages and shorter hours, will heap additional burdens on the engineer.

It is only through engineers—process, design and materials engineers—that high production can be maintained with steadily dropping costs. On them lies the task of enabling goods to be produced cheaply enough to be saleable and still provide the income that will pay increased wages and still return a fair profit for invested capital.

So, when more money is forthcoming for the organized labor groups, the engineers should not be overlooked.

—T. C. D.

Can Labor Be Educated on Economics?

Throughout the "machine age" workers have tended to be suspicious of, and openly hostile to, labor-saving devices, fearing that some machine would cheat them out of a job. Yet the facts of the matter are that the machine age has made the greatest era of prosperity that the United States and other progressive countries have ever known. One needs not enumerate the riding to the plant in workman-owned automobiles, radios, washing machines, beefsteak on the dinner table, all-wool suits of clothes, tailored with style.

However, suspicion of the machine still exists and perhaps there is more reason than ever for the ill-informed workman to be fearful. The rapid development of mass production techniques during the war placed the machine in even greater ascendancy. In five years we advanced—say 25 years.

All this, of course, is well known and repetition is boring. But it is high time that serious thought and aggressive planning is conducted on the part of management to avoid an era of more severe strikes, slowdowns, sit-downs, lie-downs than ever before. It is recognized that social engineering has by no means kept pace with branches of engineering that center around the mechanical.

What to do!

Merely use the same ingenuity that we have already displayed in promoting the machine. The workers must be taught the rudiments of economics. Technical know-how was taught in painless ways via the moving picture, clever charts and posters, and talks by executives that were not of the stuffed-shirt variety.

Do you recall a favorite movie of a year or two ago in which a clumsy stumble-bum did every technique the wrong way? That was one of the best ways of getting across a constructive idea we have seen.

And so, not only must labor be educated to respect —not fear—machines, but must be taught many more courses in human relations. This is not to imply, either, that management knows all the answers. A good teacher himself learns almost as much as the pupil in the process of teaching.

—H. A. K.

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Progress in Materials and Methods . . . A Summary

AS HAS BEEN THEIR CUSTOM for the past several years, the editors of MATERIALS & METHODS devote this January issue to a review of engineering developments in the field of materials used in the metalworking industries and in the methods of processing these materials for their ultimate uses. Thus you will find this issue divided into two separate sections with their scopes defined as follows:

Materials—In the materials section will be found discussions covering developments during 1945 in all materials used in the metalworking industries, discussed from the viewpoint of their selection and application. In addition to articles covering steels and irons, non-ferrous metals, non-metallics, coatings and finishes there is also an article covering the applications of the various types of metal parts and forms available.

Methods—In the methods section of this review are ten articles covering metal production, processing, finishing and control and inspection developments concerning the entire group of metalworking industries.

Developments of 1945

The year 1945 was unusual in at least one way. It saw the productive aims of the country brought up to a sharp halt, with the close of our two-front war, and a complete reversal of objectives. During the period of war production, materials and methods were developed and applied with little or no regard for costs—only for results. Now industry is applying the new materials and methods developed with the twin goals of bettering the product and reducing its cost.

It is inevitable that many wartime developments should now appear in the following group of articles on 1945 developments, chiefly because these developments were first made public during 1945 when secrecy restrictions were lifted. However, there are many strictly new developments born in 1945 and many refinements of previous techniques which can be credited alone to 1945.

Throughout industry, trends which received their initial impetus during the war are carrying on with increased vigor in a peacetime industry. These trends include the mechanization of all types of production processing, including heat treating, pressforming, cleaning, finishing and nearly all others; automatic machines on a much wider scale; more complete and finer inspection all along the production process; plant layout which takes into account the normal flow of material through its production and places equipment in its proper position, rather than segregating machines in one location according to function.

While neither a development of 1945 nor, necessarily, a trend, it is significant to see industry place increased reliance upon the abilities of engineers of all types. Almost extinct are the producers who refuse to adopt new methods and materials and try to operate strictly by rule of thumb and are guided by personal bias or opinion. Opinion still enters into the choice of methods, materials and individual pieces of equipment, but this type of opinion is shaped by sound knowledge and scientific fact.

The metalworking industries can claim, with complete justification, their share of credit in the No. 1 engineering achievement of all time—the Atomic Bomb—which came to a climax in 1945. In addition to producing the equipment required for this vast project, one of our industries developed an entirely new element known as Plutonium. While the release of atomic energy is now too wild and uncontrolled to be applied to industry, some of the lessons learned in achieving release of this power will gradually be made known to help all industry.

Materials and Their Selection

In the field of steels and irons we continue to see the development of special alloys for specific purposes and with specific characteristics. In 1945 there was continued emphasis on the development and use of high-temperature alloys, clad steels, the setting-up of H-Steels specifications so that steels can be ordered according to hardenability limits, rather than exclusively on a chemical composition basis.

A free-machining tool steel which oil-hardens to Rockwell 65C with very little distortion was introduced for use in cold-work dies, hard machined parts, bushings and similar service. It is said to be up to 200% faster in machining than ordinary tool steels.

During 1945 we saw a further closing of the gap between ferrous and non-ferrous alloys with the development of stainless steels and high-alloy irons along with hardenable aluminum and copper alloys. Also offering steels a stiff fight are the age-hardening engineering bronzes.

The uses of age-hardening aluminum alloys such as 75S, R301 and 24S have been extended by new artificial aging techniques. In the case of 24S the techniques have resulted in what might be called a new series of alloys.

While metals have been keeping an eye on each other, they have had to unite to a certain extent to

prepare for an onslaught from the non-metallic materials which are meeting with considerable success in tearing away old markets and applications. Here again, though, competitors have joined hands with the result that materials engineers have even better materials to choose from. Among the composite metal-nonmetallic combinations are metal-sheathed plywood, metal-rubber engine mounts, metal-plated plastic and combinations of fiberboard and plywood.

Plastics were introduced during 1945 with high impact strength, good dimensional stability and low moisture absorption. Also announced in 1945 were the silicones with many of the characteristics of plastics but having the higher heat resistance of silicon. Silicones are being used in conjunction with glass fiber or asbestos insulation for electric motors; as lubricants for motors running at elevated temperatures; as waterproofing materials and as the basis for high temperature paints.

As to the forms in which the various materials come or into which they can be made, today's production planner has about 20 commonly available choices. By any one of several methods, depending upon the material used and its ultimate size, parts can be made to intricate shapes and with close dimensional accuracy so that less final machining is required. Among the various types of parts, precision castings received the most attention.

Processing Methods

Rolling of metals to the forms in which they finally will be used has seen a mighty burst of effort with the aim of increasing rolling speeds and increasing the accuracy of thickness in the rolled sheet or plate. Finishing speeds of 5000 f.p.m. are now fairly common with 6000 f.p.m. in prospect. The past year has seen the Krause and Uni-Temper mills emerge from the experimental to the practical stage and the introduction of the Sendzimir mill for rolling stainless steel to an accuracy of 0.0001 to 0.0003-in.

Press forging has emerged from the war as one of the most important forming methods available. Sizes and intricate shapes once thought impossible are now being produced to almost unheard of tolerances. Recently we have been told of crankshafts being forged complete with counterbalance and cranks in correct position with only two strokes of a 4000-ton press. Tolerances of as little as 0.0156 in. are now possible without additional coining or sizing operations. Hydraulic and mechanical forging presses are increasing in size, there now being a mechanical press with capacity comparable to a 12,000-lb. steam hammer, which will weigh 1,300,000-lb.

The soft die materials being used for pressforming have made practical the use of this forming method on runs from a few pieces up to four or five hundred pieces. Experiments are being conducted with oil or water as the forming medium in a variation of the Guerin process. Water is said to produce more complicated shapes with greater accuracy than rubber.

Machining has seen demonstrations during 1945 of the ability of solid carbide tools to remove terrific quantities of metal at extremely high speed rates and with finishes down to a few microinches. These results are true with the light metals, ordinary steel, fibrous steel and extremely tough armor plate.

As to the machines themselves, the few new machines introduced during 1945 show the culmination of recent trends toward automatic equipment. One new vertical turret lathe works equally well under manual or automatic operation. When performing automatically it will go through as many as 39 functions on one individual piece without any more attention than pushing one button once.

Outstanding in welding during 1945 was the introduction of a process known as multi-arc welding. Its value has already been demonstrated in welding difficult alloys in thin gages—especially non-ferrous alloys such as 24S, R301, 75S, R303, magnesium 3S and 57S, silicon bronze and such steels as 4130, 8630, 1020 and 18:8 stainless. Many of these metals were once considered unweldable.

Inspection and Control

The production of war material showed the need for inspection of the interior portions of parts and materials. This resulted in the vast growth of radiography. As a matter of fact, scarcity of X-ray equipment and limitations of radiography led to the latest inspection development—supersonic inspection.

Supersonic inspection—announced in December 1945—uses miniature radio sending and receiving sets to seek voids and cracks in steel, iron, rubber, plastics and other materials. Based on the knowledge that ultra-high-frequency radio waves pass through solid materials at set rates, voids are discovered when the rate varies due to the waves passing through air. A forerunner of the method was used to inspect rocket powder grains for voids. Among the principal applications for supersonic inspection are the testing of steel sheet as it leaves the rolling mill and the testing of laminated plastics to see that complete bonding has taken place.

As far as control of metal working applications is concerned, probably the most outstanding development of 1945 is a type of regulator which anticipates the rise and fall of furnaces temperatures and acts accordingly so that temperatures will vary less than results from former temperature equipment.

It is impossible, in an introductory article of this nature, to do more than point out a few of the highlights of the past year. We are sure that it will be well worth the reader's time to follow through to the subsequent articles to learn more completely the details of these developments and many others that are discussed.

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The outstanding broad trend in ferrous materials engineering is the increasing emphasis on alloy steels for various specialized properties. (Courtesy: Inland Steel Co.)

Steels and Irons

Reviewed by Fred P. Peters

THE PAST YEAR in materials engineering (as in most other technical fields) has been characterized by the maturing of developments started prior to 1945 and by certain shifts in applications caused by the war's end, rather than by any wholesale development of strictly new materials. Indeed an annual review of *significant* new materials developments cannot lean too heavily on the "new" aspect, for it is generally difficult to appraise the true significance of anything new until it has been in use a few years; as Gillett once said in referring to this situation: "How do you know how a kid in diapers will wear his football pants?"

But it is possible to record that certain new materials have been introduced and in a broader way to indicate the position of the whole field of materials engineering today as compared with our position a year or so ago. What are the broad trends in application and development? What developments made prior to 1945 have moved ahead or received specially heavy use in 1945? What individual types of materials have picked up such momentum in 1945 as to indicate likely changes in their future importance to engineers and production men? What brand new materials of any promise have been introduced to the market?

Even though we can't visualize the fit of the football pants 12 or 15 years hence, let's see how the clothes the youngster has *now* fit him, and if he's any bigger than he was a year ago. This, then, will be our purpose in reviewing the materials developments of 1945 in this and the following articles.

There were a number of new iron-base materials introduced or pushed into new prominence in 1945—the "super" high-temperature alloys, a high-nickel steel for low temperature use, a new titanium-bearing enameling steel, boron-containing malleable iron, a low-chromium corrosion-resistant steel, silicon-chromium spring steels, certain electrical alloys and so on. The introduction and publicizing of others—for example new age-hardening grades of stainless steel—are imminent and will probably class as 1946 advances.

Trends in Ferrous Materials Engineering

The outstanding broad trend in ferrous materials engineering is the war-impelled and still increasing emphasis on *alloy* steels. These seem to be the steel industry's strategical answer to the implied threat from the direction of the light metals, the carbide tool materials, the plastics and plywoods, etc. New alloy, stainless and tool steels have met the need for improved strength/weight properties, better heat-, corrosion- and wear-resistance, and various specialized properties.

The development and specification of alloy steels have been carried forward with especial attention to working properties and costs. Steel specifications based on hardenability (the "H" steels) have been formulated. Steels of various types have been produced specifically to be more easily welded; others have been made deliberately to behave better in welded structures; research on steel weldability has been pushed. Machinability factors, with particular emphasis on behavior with carbide tooling, with new lubricants and after heat treatment, have been the subject of much attention.

The composite or clad steels as a class are receiving increasing application, with stainless clad steel leading the parade. Copper-clad, nickel-clad, Inconel-clad steels and other duplex materials—either clad on one side only, or "sandwiched"—have also found wider

use. The use of a relatively thin surface layer of a high-cost material with specially needed surface properties, backed up with a thicker, rigid, inexpensive body material is a sensible application of the best properties of each material where needed most and appeals to an ever-larger number of engineers.

Cast steel, cast iron and malleable iron have found new friends in 1945. Alloying and wider use of better heat treatments have marked their progress, with a noticeable trend toward the successful use of cast ferrous materials in services once considered much too severe for any of them.

In general, steels and irons may lose some end-use applications to other materials. But the steel industry is not standing still; it is developing its special answers to the challenge from without and in any case is certain to find new markets for its products in machinery and equipment to produce and fabricate the new competitive materials.

High-Temperature Alloys

Virtually all observers of the materials-engineering picture rate the development and use of the new "super" high-temperature alloys as the outstanding advance of recent months. Of course, work on these alloys (as a specific problem) started early in the "emergency period," and some of the materials finally used have been in existence for a long time, but considerable data about their analyses and use were released during the past year.

As is now well known, the successful production of turbosuperchargers, gas turbines and jet propulsion units depended on finding materials that would withstand the 1200 to 1500 F temperatures at which many parts of such equipment must run continuously. The usual heat-resistant materials either scale badly or lack strength or stability under load at these temperatures.

The materials developed and finally used overcame these limitations individually, and by careful application of the previously available materials where they could be used and of the newer "super" materials (often expensive or heartbreakingly difficult to fabricate) for only the most severe-service areas or parts, the problem was satisfactorily solved. "Satisfactorily," that is, from the emergency standpoint of winning a war (the very latest high-temperature materials increased the operating life of aircraft jet propulsion units about 100%); actually the search goes on for even better materials to permit important improvement in the thermal efficiency of gas turbines and their brethren.

Most readers are familiar with the use of Vitallium (65% cobalt, 30 chromium, 5 molybdenum) and the related tungsten bearing Stellite alloys for turbosupercharger blades and buckets and for similar parts of gas turbines and jet turbines. Such alloys are exceptionally strong, highly corrosion resistant and heat resistant, but they are also virtually impossible to machine and forge; they were made into parts by the millions, however, by precision casting ("lost wax" or investment casting) methods which permitted these intricate parts to be produced directly to close tolerances without any machining.

The nickel-base alloys such as Hastelloy, K-42-B, and Inconel also served in critical areas of jet propulsion equipment. A new variety of Inconel (Inconel "X"—75% nickel, 14 chromium, 6 iron, 3 titanium and 0.6 aluminum) is now used for combustion chambers. In at least one engine a special grade of pure nickel was fabricated by spinning and used for torroidal joints in the high-pressure combustion chamber inlet because of its combination of relatively low expansion coefficient and good heat-resistance.

For impellers in aircraft jet-engines a new iron-base alloy containing 16% chromium, 25 nickel, 6 molybdenum and 0.08 carbon was employed. Another modified stainless steel (19% chromium, 9 nickel plus tungsten and molybdenum) was fabricated from plate and forgings into parts operating at 1100 to 1300 F in marine gas turbines. S.A.E. 4130 has been used for ducts that reach 1100 F in service, and compressor shafts in jet engines employed S.A.E. 4140 for its combination of high-temperature strength, satisfactory oxidation resistance and workability.

Gray iron is now used for a surprising number of gas turbine and jet propulsion components, an indication of growing respect for the high-temperature properties of modern irons. Despite the ancient codes that still restrict the use of "cast iron" to service under 450 F, many special irons are now available for 450 to 1000 F temperatures. One survey of 100 companies published during the year unearthed data on 223 applications of cast iron at temperatures over 450 F and up to 2,000 p.s.i. in steam and internal combustion engines, furnace, power, petroleum, paper, chemical and metallurgical industries.

The survey showed a room-temperature tensile strength greater than 35,000 p.s.i. to be a common characteristic of the heat-resistant irons. Some gray irons can resist loads of 10,000 p.s.i. at 750 F without creeping more than 1% in 10,000 hr. At higher temperatures load bearing ability is much less but often satisfactory; thus one heat-resistant special-process iron creeps 0.4% in 1,000 hr. under a load of 1,000 p.s.i. at 1400 F.

High-temperature research made progress in 1945, although research developments are always over in the difficult-to-appraise "diaper" stage mentioned by Gillett. The practical problem of preventing graphitization in steels for high-temperature piping was successfully attacked. An extremely able study of the sigma phase in high-temperature alloys showed it to be more than a trouble-making metallographic monstrosity, and indeed to have certain definite advantages when it is recognized and exploited for what it really is. One important and still-continuing project is

Transportation equipment has spotlighted the demand for low-alloy high-strength steels to compete with the light metals. (Courtesy: Inland Steel Co.)

directed toward a factual evaluation of the effect of nickel and chromium variations on the high-temperature corrosion resistance of heat-resistant alloys.

New Special-Purpose Steels

Through the development of a new fine-grained titanium-bearing steel (christened Ti-Namel) manufacturers of vitreous-enameled products now have a base stock on which they can apply white or light-colored single cover-coat enamels without prior applications of a ground coat. The titanium, present in the steel in proportion to the carbon content, reduces or eliminates pitting, black specks and blisters when the steel is enameled.

The thinner coats of enamel thus made possible have less likelihood to chip. Processing in the enameler's shop also involves less waste and therefore lower costs. The steel does not strain-age; its drawing properties are comparable to those of autobody stock, and even large shallow parts retain their flatness and shape after drawing.

A new steel introduced during the year was developed especially to have superlative mechanical properties at sub-zero temperatures. Containing 8 to 10% nickel and less than 0.12% carbon, the new material is capable of giving Charpy impact values of 25 ft.lb. at minus 320 F. In the form of normalized tubing its minimum tensile properties (at room temperature) are given as 80,000 p.s.i. ultimate strength, 50,000 yield strength and 20% elongation in 2 in.

According to its developers the new product may be applied in low-temperature work in place of the conventionally-used 18:8 stainless steel tubing, and appears to have especially interesting possibilities for oil refinery and chemical industry applications. Its corrosion resistance is one of its chief features, so that its most natural fields of use will be those applications requiring a combination of resistance to chemical attack and to low-temperature embrittlement.

With the builders of transportation equipment of all types striving for the lightest possible weight consistent with safety and cost considerations, interest in the light metals and in the strong steels for achieving that purpose has intensified in the last year. Two new low-alloy high-strength steels entered the lists to bolster the ranks of the lower cost high-strength materials.

One of these (Aldecor) is of the traditional class of high-yield-strength, low-alloy steels with corrosion-resistance superior to copper-bearing steel and good formability and weldability as-rolled; its distinguishing feature is an imposing array of alloying elements, the composition ranges being 0.25-1.5% chromium, 0.25-1.5 nickel, 0.07-0.6 molybdenum, 0.08-0.75 copper, 0.07-0.18 phosphorus, 0.50 max. manganese, and 0.14 max. carbon. Not only does the amount of each constituent serve a special purpose with respect to strength, corrosion resistance, or processing behavior but the whole composition is designed to provide a nice outlet for the tri-alloy scrap which will continue to come back to the steel mills in distressing amounts for the next few years.

Another new low-alloy steel is "Jalloy," which is produced in three carbon-content grades; low-carbon for high ductility formability and weldability in the as-rolled condition; high-carbon for abrasion-resistant applications; and medium carbon for low-alloy shafting and other uses. The medium- and high-carbon grades benefit from heat treatment and in this respect Jalloy differs from most of the other low-alloy steels, which are conventionally produced for use in the as-rolled state. Jalloy is described as also retaining good toughness down to sub-zero temperatures.

Relatively new to American makers and users of springs is a silicon-chromium spring steel composition imported from England. Successfully used for recoil springs on anti-aircraft guns and for certain kinds of torpedo-springs, the material has very high tensile strength and hardness, and is reported to withstand shock loading much better than carbon steels and to compare favorably with S.A.E. 6150 steel in this respect. Its chemical composition is 0.50-0.60% carbon, 0.60-0.90 manganese, 1.3-1.6 silicon and 0.5-0.8 chromium.

Boron in Malleable and Gray Iron

An important recent development in malleable iron is the addition of boron to the iron, in retained amounts between 0.001 and 0.003%, for the purpose of reducing annealing time, especially in the presence of chromium. Undesirable amounts of the latter are often inadvertently introduced via the scrap and of course tend to prolong the required annealing

time. The boron not only acts as a safety-first agent against such adventitious chromium, but also permits the practical utilization of special chromium-bearing irons, at the same time that it develops a finer graphite structure in the iron.

During the year a report appeared of the use of boron-containing cast iron for cylinder liners in sludge pumps. The iron was described as an electric furnace product containing 0.7-1.26 (*sic*) % boron, having a hardness of 67-70 Rockwell C, and capable of outlasting ordinary steel cylinder liners nine-to-one.

The "H" Steels

Advances in the application of individual materials and in methods and bases for specifying them are also worth attention. One of the foremost of these has been the promulgation by the American Iron & Steel Institute of the "H" Steels specifications, with which it is now possible to specify engineering alloy steels of all standard types to *hardenability* limits. This of course represents a radical departure from the conventional system of specifying steels exclusively on a chemical-composition basis only.

By using "H" steel specifications, the steel-user does not have to worry about the occasional off-hardenability heats normally encountered when steel is ordered to chemical-composition specifications only. On the new basis the chemistry may not be exactly what the user might expect but the *hardenability*—obviously of much greater practical importance to him—will be within ranges specified. This will not only enormously simplify the user's heat treating problem but will also aid the producer in fulfilling the requirements imposed upon him.

The "H" steels are identified by the letter "H" following the usual numerical designation (e.g. 8730H, NE 9440H, etc.). Such steels are produced to conform to specific end-quench hardenability limits, which are based on hardenability bands for each steel tentatively established by A.I.S.I. and S.A.E. committees after careful analysis and evaluation. For those to whom hardenability problems are critical, the "H" steels are definitely the answer.

Electrical Alloys and Tool Steels

Technical data on the electrical sheet steel Hipersil for transformer laminations and related uses were issued during the year. Although the material itself is now a few years old, recent advances have further improved its magnetic properties, so that today Hipersil gives 20 to 30% higher flux densities than ordinary hot-rolled silicon steel, and therefore permits a 20 to 30% reduction in core cross section.

Hipersil is a 3 to 4% silicon steel, rolled and heat treated to produce the greatest possible crystal orientation. A special annealing process lowers the oxygen, carbon and sulphur to a minimum, with consequent lower hysteresis losses and greater crystal orientation.

Among permanent magnet materials, the superalloy Alnico V continues to attract increasing interest. Experimentation with precision cast permanent magnets goes on although no public announcement of the results has been made. A boom is expected to develop in magnetic tape or magnetic wire materials once the remarkable method of recording and reproducing sound that is based upon them is applied in consumer phonographic equipment.

In the tool steel field, the tungsten type high speed steels recovered much of the ground lost to the high-molybdenum high speed steels (such as 6% tungsten, 6 molybdenum compositions) but the latter are "here to stay" in considerable amounts—like many other worthy wartime "substitutes."

A new free-machining tool steel known as "Dunkirk EZ" was placed on the market last year. It is described as having 25 to 200% faster machinability than the usual tool steels and to be quite outside of the ordinary tool steel specifications in many ways. It is an oil-hardening (to Rockwell 65 C), very slightly distorting steel with good impact and transverse rupture strength and exceptional wear resistance. It is suggested for use in cold-work dies, hard machined parts, bushings, etc.

An important trend is evident toward the use of tool steel tubing in place of bored out hard steel rods for many parts. The tool steel tubing often saves much time and expense in producing a hard steel ring, bushing, arbor, annular die, liner, sleeve, etc., and can also simplify the problem of achieving full hardness where desired without excessive distortion.

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Non-Ferrous Metals and Alloys

Reviewed by Fred P. Peters

THE DISTINCTION THAT all of us have traditionally drawn between "ferrous" and "non-ferrous" metals, while very real, has become increasingly academic in importance. The borderline between ferrous and non-ferrous alloys has been blurred by the newest stainless steels and other high-iron alloys, at the same time that hardenable aluminum and copper alloys are being developed whose properties make them directly competitive with the cheaper heat-treated steels.

Indeed the oustanding current trend in non-ferrous materials is the continual closing of the engineering-properties or the economics gap between them and the steels. The light metals for example are "inching up" on their ferrous cousins with respect to strength, durability and workability. The engineering bronzes are challenging the steels on many new fronts, with some recently developed age-hardening members of this clan leading the way.

Beyond that the non-ferrous metals are increasingly competitive among themselves. The materials and process engineer cares little, therefore, whether he selects a "ferrous" or a "non-ferrous" alloy, or, if the latter, whether its base be copper or aluminum or magnesium or zinc—he regards them all as competitors for his favor and chooses that one which best fits the complex service and production requirements of each application.

Specifically, the last year has witnessed much activity among new high-strength aluminum, magnesium and copper alloys; the weeding out of the wartime substitute alloys and the retention of a few (e.g. the antimonial solders) as evidently permanently worthwhile materials; the sharply increasing use of hard carbides for wear-resisting parts; and the beginning of the drive for new peacetime applications for the metals whose production capacities have been tremendously expanded by the war.

In our opinion the No. 1 "new material" development that came to public attention during the last year was the creation of plutonium, the atomically unstable synthetic element (molecular weight: 239) made by neutron bombardment of "light uranium" (U-235). Plutonium, the chief fissionable material of the atomic bomb, represents the first time in his history that man has created a new element. The story of that achievement, as presented in the Smyth report, was tersely outlined in the leading article in our October 1945 issue.

Aluminum and its Alloys

The light metals took a long step toward achieving the strength of carbon steels when the aluminum alloys 75S and R301 were developed and placed in use in 1943 and 1944. During 1945 more information about the composition and treatment of these new high-strength materials was released, while some new aluminum alloys—R303 and R317—became generally available. The application of artificial aging to clad 24S aluminum alloy resulted in the 24S-T80 series of super-strength aluminum alloys.

Alloy 75S, which contains 5.75% zinc, 1.6 copper, 2.5 magnesium and small amounts of manganese, chromium and titanium, is now available in the form of clad sheet, bare sheet, extrusions and under certain conditions as plate, bar, rod and tubing. New artificial-aging recommendations made during the year provide for either a 24-hr. aging at 250 F or an "interrupted aging" (4 hrs. at 210 F, cool to room temperature, reheat 8 hrs. at 315 F) after the usual solution treatment. In addition to being shorter, the interrupted

Aluminum Alloy 75S, a high strength age hardening material, approaches the strength of carbon steels, as do some of the other new aluminum alloys.

aging practice gives a material with equivalent tensile strength, better corrosion resistance and better dimpling capacity but lower tensile strengths when coupled with cold work after quenching, as compared with single-temperature age-hardened material 75ST extrusions reach 88,000 p.s.i. tensile strength; other forms of the material in the T temper have tensile strengths between 76,000 and 82,000 p.s.i.

R303 is a similar type of alloy, also with zinc, magnesium and copper as the principal alloying agents. It is now available as clad sheet, bare sheet, plate, bar, rod, extrusions and forgings. The recommended heat treatment is to solution-treat at 825 F, quench, "incubate" for 24 hrs., and then either age 8 hrs. at 315 F or 25 hrs. at 275 F. The lower-temperature hardening treatment produces the better mechanical properties, e.g. about 84,000 p.s.i. tensile for heavy R303-T275 extrusions as against 77,000 p.s.i. for similar-sized R303-T315 extrusions.

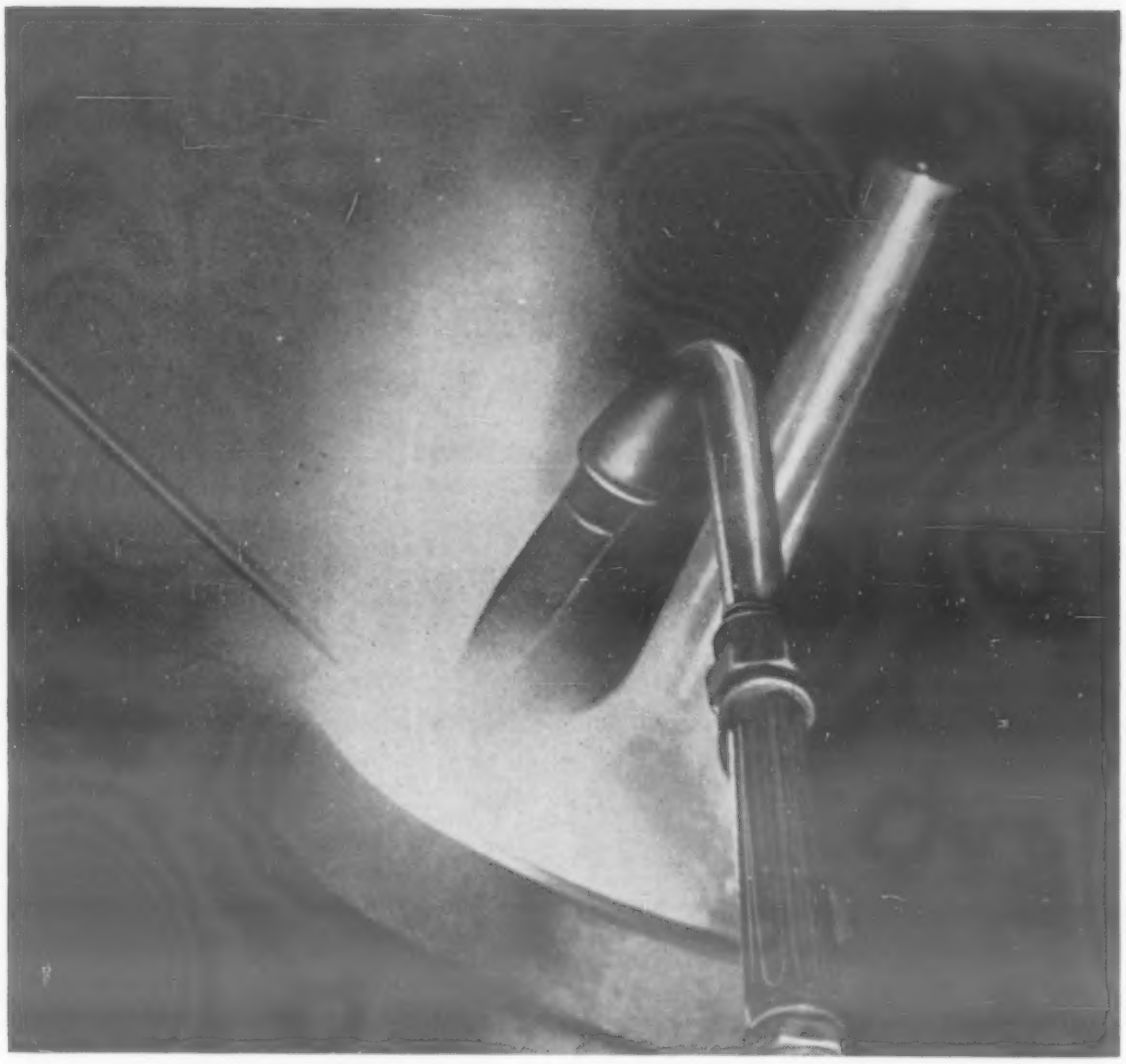
R317, another new aluminum alloy, is a new free-machining material with mechanical properties similar to 17S alloy, and is available as bars and rods.

One of the outstanding aluminum alloy developments of recent months is the discovery of artificial-aging cycles for clad and extruded 24S alloy sheet which, when combined with cold work, have resulted in what is virtually a new series of alloys—24S-T80, -T81, -T84 and -T86—with tensile strengths as high as 72,000 p.s.i. for the last-named in the clad form. The highest strength materials in this group are somewhat lacking in ductility but with intelligent handling they can still be considered as easily-worked alloys.

Aluminum casting alloys containing beryllium (e.g. aluminum-copper-beryllium and aluminum-copper-beryllium-cobalt alloys) were shown to have superior strength properties together with high thermal stability and unusual oxidation resistance. A promising composition is 3.8% copper, 0.2 beryllium, 1.3 cobalt, remainder aluminum.

Other new aluminum alloy products of 1945 included 63S, designed particularly for architectural and building applications, and clad 14S sheet. Aluminum alloy bearings are discussed in later paragraphs. Thirty-two aluminum tank cars were added to the country's railroad equipment, with 50 more on order. The "battle of the box-cars" waxed hotter, a typical case being three (for one railroad) that had complete aluminum superstructures, including side frames, sheathing, ends, roofs, doors, etc.

Experiments under way on the use of aluminum axle housings for heavy duty trucks and trailers indicate possible weight savings of 500 lbs. per unit. The aluminum piano plate, which retains the musical qualities of the traditional cast iron plate but weighs only ⅓ as much, was a 1945 development. And if the Ordnance Department's experimental can-



Beryllium copper, which these springs made, has a new ri for mechanical spri diaphragm and bell applications in a n age-hardening copp manganese-nickel all (Courtesy: Instrum Specialties Co.)

Right: Ultra-hard materials are finding greatly increased application in all types of service. Included are the carbides and such alloys as a new nickel - chromium - cobalt - tungsten material which is used for faces and valve seats.

ning program is carried out on a large scale, several hundred thousand lbs. of aluminum sheet will be used in 1946 for aluminum containers for the long-time storage of ordnance equipment, from small arms to artillery and tanks.

Magnesium Alloys

New magnesium alloys are also being steadily introduced. A new sheet material (251X) containing 5% aluminum and 1 zinc, with better ductility and toughness than ordinary magnesium alloy sheet, was brought out in 1945. Also, American users may now have magnesium-cerium alloys containing 4 to 6% cerium and 2 manganese, which are exceptionally useful for pistons and other high-temperature applications. Finally, a new high-strength magnesium alloy containing zirconium and reported to have tensile strengths as high as 65-70,000 p.s.i. and to be workable as sheet and extrusions, has aroused much interest.

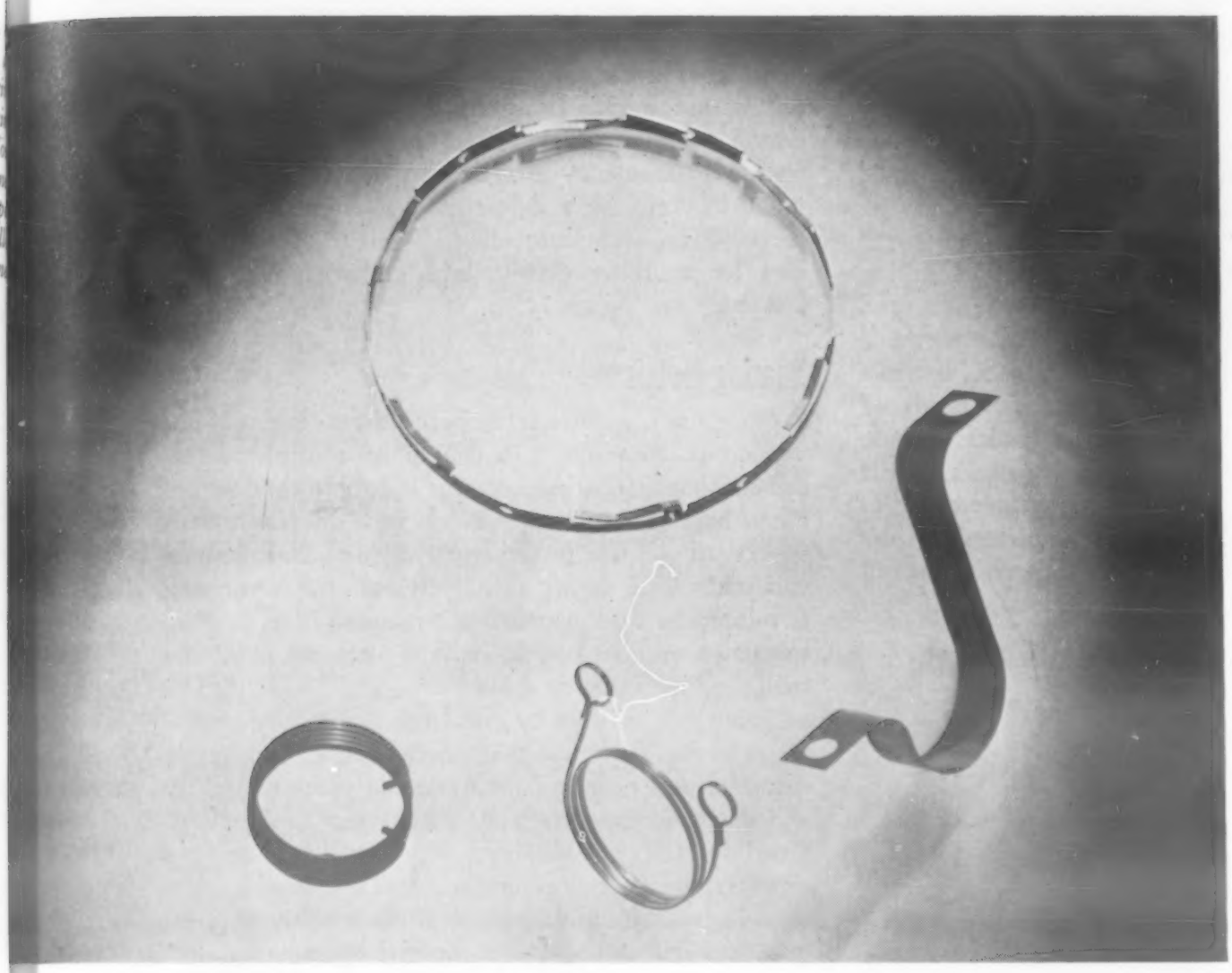
During the year scientific proof was presented that solid magnesium does not burn; the metal must be molten before it will catch fire. Practical proof of this has abounded, the latest example being the success of the magnesium griddles and grills now coming onto the consumer market.

Long-time corrosion tests performed under scientific control at the North Carolina seashore have revealed a number of interesting facts about modern engineering materials, among them that magnesium alloys—contrary to widely held impressions—are surprisingly resistant to salt-air corrosion.

Copper Alloys

That copper and its alloys are just as much in the materials engineering picture as they have ever been is shown by the recent development of new age-hardening copper alloys, several free-machining materials and a generally aggressive and successful assault on peacetime markets. One of the best tributes ever accorded copper alloys was the enormous sigh of relief that arose when copper became sufficiently plentiful late in the war to permit virtual abandonment of the steel cartridge case program, and the restoration of brass as the regular cartridge case and shell case material.

Widely publicized during the past year was the commercial introduction of an age-hardening copper-



manganese-nickel alloy (Alloy No. 720, containing 60% copper, 20 manganese and 20 nickel). The new material appears to be a rival for beryllium-copper for mechanical spring, diaphragm and bellows applications. It can be precipitation hardened to 200,000 p.s.i. tensile, has excellent corrosion resistance, requires a lower solution-treating temperature than beryllium-copper, and according to some users does not require as close control during its age-hardening to assure uniform as-hardened properties, as does beryllium-copper.

The new alloy is described as having freedom from drift and high fatigue strength, comparable to beryllium-copper. However, it has a relatively low electrical conductivity and is therefore not recommended for brush springs, fuse clips, contact fingers, etc.

Alloy No. 720 is also available as forgings, in addition to wire and strip forms. The heat-treated forgings find use where a combination of corrosion-resistance, wear-resistance, high strength and non-magnetic properties is required.

Another interesting new alloy is Phosnic, a precipitation-hardening nickel-phosphor bronze containing 1.10% nickel and 0.20 phosphorus. This material has a high conductivity (about 90%) and is hot- and cold-workable and corrosion-resistant as well.

Copper and copper alloys containing tellurium, which feature free-machining properties combined with strength, corrosion-resistance and/or conductivity are coming into increased use. Thus 0.5% tellurium in the nickel-phosphor bronze just mentioned makes it a free-machining alloy (Telnic). A tellurium-bearing aluminum bronze (9.5% aluminum, 1 iron, 0.5 zinc, 0.5 tellurium) provides very high strength, excellent corrosion- and oxidation-resistance plus hot-workability and free-machining quality. Free-machining tellurium-bearing copper rod has been extremely helpful to electronic, electrical and screw-machine-product manufacturers seeking a high-conductivity, corrosion-resisting metal with free-cutting properties.

Ultra-Hard Materials

Developments among the super-hard materials such as cemented carbides (tungsten carbide, titanium carbide, tantalum carbide and their combinations) primarily considered as cutting-tool materials, and boron carbide, have brought them into widening use as materials for wear-resistant mechanical parts.

An article in our October 1945 issue described the applications of boron carbide for gages and similar parts. Tungsten carbide and its relatives are now being used for gages, guides, bearing sleeves, spray nozzles, valve seats, Brinell balls, ball bearings, mold linings, lathe and grinder centers, etc.

The outstanding recent development among the cemented carbides is their use as dies for blanking and forming sheet metals and other materials, and for heading and punching as well. In one case a blanking operation that usually went 90,000 times between grinds with high speed steel dies produced 50-60 million pieces between grinds with carbide dies. In another case a set of carbide blanking die inserts produced more than ½ billion pieces from 0.025-in. electrical steel sheet without excessive wear or failure. The carbide dies have also been successful on plastics, paperboard, etc., and on metal thicknesses greater than 7/16 in.

A new hard material, Eatonite, a nickel-chromium-cobalt-tungsten alloy, that maintains its hardness well at red heat was announced late in the year (see page 1744 of our December 1945 issue). Its primary field of application appears to be valve faces and valve seats but other uses are being studied.

Another new hardfacing material contains tantalum-columbium carbides and gives a porous surface that retains lubricant well. It is being applied to hot-work punches, dies and tools, no hardening treatment being necessary.

Lead, Tin, Zinc and Bismuth Alloys

Among the wartime substitute solders most have fallen from favor except (1) the 80 lead/20 tin solder, which has been shown to be every bit as serviceable and practical as 40/60 solders if certain simple precautions are observed in its handling, and (2) the antimonial solders, which are turning out to be very popular indeed. The latter, containing fractional percentages of tin and arsenic, and usually 4 to 6% antimony have performed (in the opinion of many) better than the 80/20 solder. Successful applications have included can-soldering, electrical and radar work, general repair and autobody work. They are widely believed to be the most likely of the war-developed substitutes to remain as commercial peace-time solders.

A new bismuth base alloy (the eutectic alloy of bismuth and tin containing 58% bismuth) called Cerrotru was introduced, with almost no change in volume while passing from the molten to the solid state and on aging. It melts at 281 F. It is used for castings where near-perfect retention of mold detail or dimensional accuracy is required. Another new bismuth alloy containing indium was developed which melts at 117 F but is still relatively expensive.

Outstanding developments in zinc alloys were the introduction of zinc alloy extrusions, described in our December 1945 issue, and the use of Kirksite dies for blanking, for stamping and deep drawing heavier materials and longer runs. In one case 25,000 deep-drawn stampings were made out of 0.024 in. sheet steel with zinc alloy dies; in another 1000 blanks of 0.050 in. stainless; and in still another 30,000 blanks of 0.062 in. aluminum alloy. The use of zinc alloy dies for molding plastics and rubber has also increased.

Bearing Metals

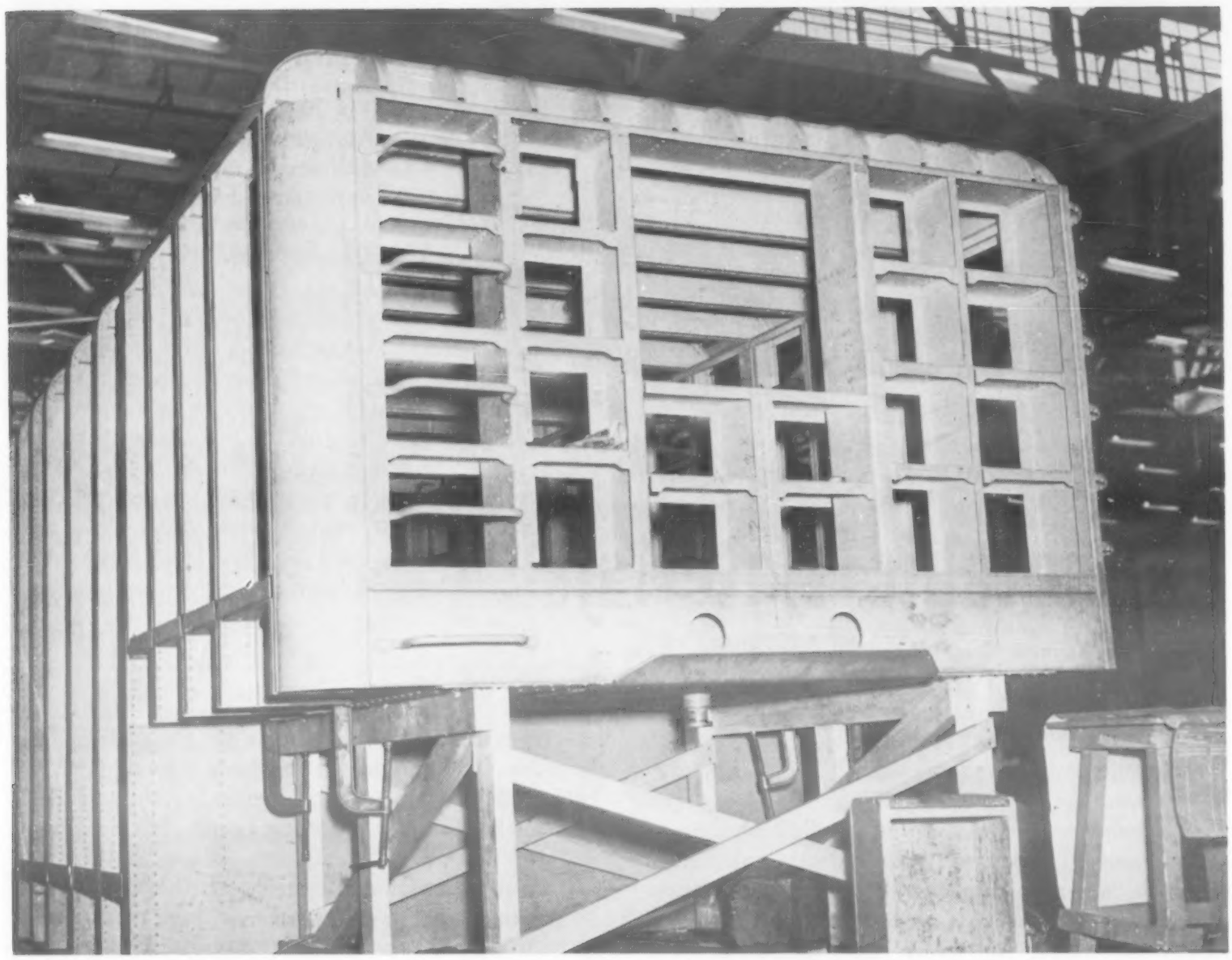
Once upon a time it was considered essential for a good bearing metal to consist of a duplex hard-and-soft-constituent structure, as in babbitts and white-metal bearings generally. Work done on pure metals and coatings prior to the war had just about pushed this antiquated theory into oblivion, and continuing development and use of such single-phase bearing metals as pure silver and indium plate has evidently furnished the coup de grâce.

Thousands of tests by one large automotive manufacturer demonstrated that silver bearings, properly designed and processed, can provide greater capacity and fatigue strength than other types of bearings. Good results were obtained with the silver bearings whether thermally or electrolytically bonded. Bearings for aluminum crank cases, made with stainless or bronze backs had lower thermal-expansion differentials and hence thinner-wall bearings could be used. Improved performance was obtained by indenting the surface and filling with lead.

Silver-thallium alloys were developed and tested, the thallium being present as a 2-3% alloy in silver, prepared by fusion or diffusion methods. A 2% thallium alloy had good anti-friction properties and good corrosion resistance for such alloys—better indeed than that of silver-lead or copper-lead materials.

Since the tin shortage is still with us efforts to develop suitable low-tin substitutes in the bearing bronze field have continued. One of these, described late in the year, is a nickel-antimony-lead bronze (2.5-8% nickel, 10 lead, 1 antimony), which has a Brinell hardness of about 50 and wear resistance superior to standard 80-10-10 bearing bronze. The nickel-antimony bronze has lower tensile and yield strengths than the standard leaded bronze; however, if 2% tin is included in the composition along with 8 nickel, 10 lead and 1 antimony, the yield strength is comparable to that of the standard alloy.

One of the large auto builders developed a 35-40% lead, 5 silver, some iron, copper-base bearing alloy, called Tri-Alloy bearing metal. The metal is not subject to lead segregation and stands up well under heavy loads at high speeds. In road tests some bearings and crankshaft journals showed no wear after 50,000 miles. The new bearing alloy wears at about the same rate as cadmium bearings, but costs more than the latter.



In the battle of materials, aluminum is being used for passenger and box cars for railroad service and for such applications as this experimental refrigerated truck.

Aluminum bearings made new friends during the past year. The aluminum-tin bearing alloy, which has excellent fatigue properties and wears well against hard and medium-hard shafts, would be even more widely used if tin were more plentiful. Aluminum powder metallurgy bearings also increased in use.

The use of carbide-to-carbide bearings has been established as a feasible and sound arrangement. In one application employing tungsten carbide for both the shaft and the bushing of a grinder for die nibs, the bearings wore no more than 4 microinches in a year, whereas the steel ball bearings previously used lasted less than two weeks.

Other non-ferrous alloy developments involving more the *form* in which the material is made rather than its composition are reported in the article on "Parts and Metal-Forms."

We acknowledge with genuine appreciation the aid of the following in providing information presented in this review:

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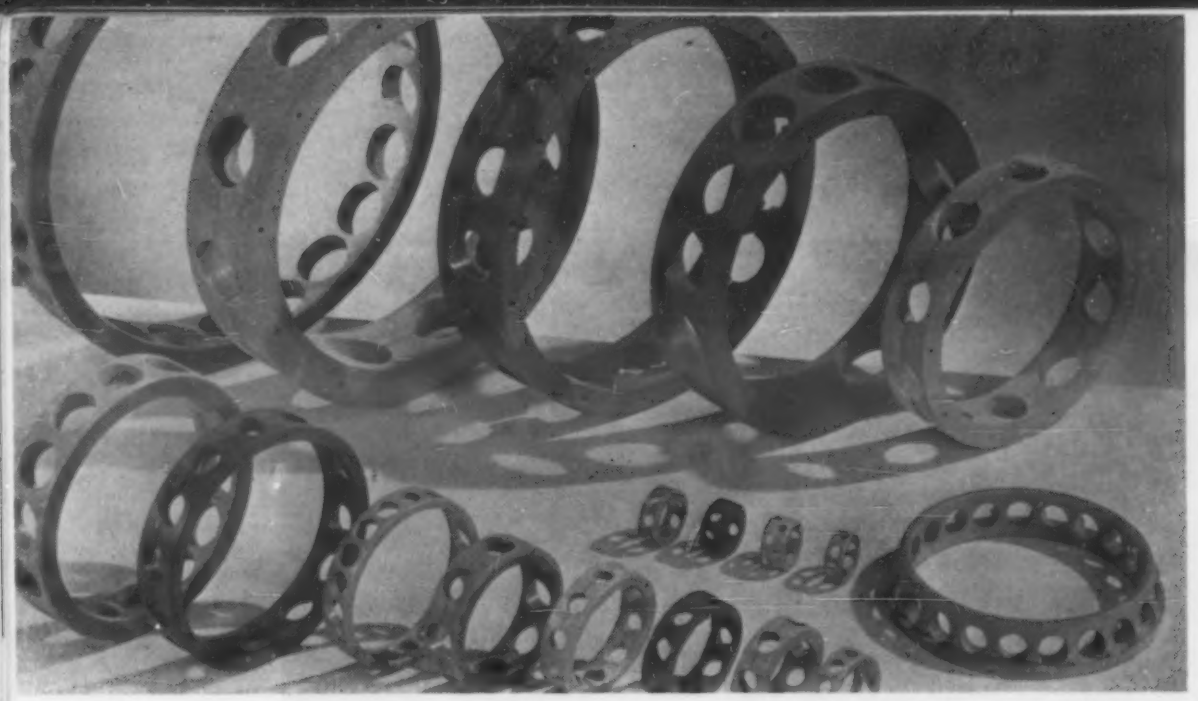


Among parts once exclusively made from metals and now being made of nonmetallics are high-speed ball bearing retainers. Fabric-base laminated tubing is the material. (Courtesy: Bakelite Corp.)

Nonmetallic Materials

Reviewed by Kenneth Rose

STEEL STRIKES THE KEYNOTE of our modern world, in peace as in war. It is certainly the backbone of industry as we know it today. Because of its strength and ease of fabrication by high production methods it has become the preferred material of construction over such things as wood for railway cars, automobiles (as against wagons), refrigerators (as against iceboxes), and much household equipment. The years immediately preceding the war had seen improved wood products returning to challenge steel in many of the fields that had been lost, and new competitors arising from among the plastics, glass, rubber, ceramics and other nonmetallics. The glass frying pan, screens of plastic filaments, and the plywood boxcar have been recent arrivals upon the scene, indicative of inroads made by the nonmetallics into fields where steel had been firmly established.

Engineers recognize the growing importance of a great variety of materials known as composites, or as sandwich materials. Offering enormously varied properties through combinations of unlikes, these co-materials have already given us the diesel locomotive cab of metal-sheathed plywood, the wood-faced metal radio cabinet, the metal-rubber engine mount, the metal-plated plastic closure, the fiberboard-plywood aircraft partition, and many others. New adhesives of high strength and versatility have given the engineer the opportunity to name his own choice of combinations.

Certainly the most widely publicized of the nonmetallic materials of construction is that group called the plastics. Their wartime growth and development has been tremendous, and they have been prompt in their swing to nonwar applications.

Trends during the past year in the plastics field have been the striving for moldable thermoplastics of higher service temperature ranges, the considerable increase in the use of electronic heating for molding of thick sections, and the advances in low pressure and contact pressure laminating. The first has been shown by the introduction of several new types of materials, to be described later, while for the second it has been estimated that more than 40% of thermosetting plastics are now heated electronically when molded. Use of this type of heating makes possible the successful molding of thick sections; it is also favored for molding cotton filled impact materials.

For the third item, activity in the low pressure fields has resulted in production of such large pieces as molded plastic boat hulls, plastic coffins, luggage, and instrument cases. Pressures of 1000 p.s.i. and less permit use of inexpensive molds of wood, plaster of paris, etc. Rubber bag molding has also been made possible, and use of simpler presses.

Production of plastic sheets by continuous extrusion has been accomplished successfully on a limited scale, and will probably be announced for large-scale production within a few months. Production costs will be lower than for present methods, which include skiving from block or pressing between polished plates.

Plastic films are being produced by spraying thick solutions onto stainless steel belts, evaporating the solvent during the belt travel.

Several New Plastics

Several new materials were added to the already long list of plastics. The development of a new cellu-

losic plastic, cellulose propionate, was announced late in the year, and while large-scale plant construction was still underway the output of a pilot plant was available to industry. Offered under the trade name, Forticel, the material possesses high impact strength, good dimensional stability, and low moisture absorption. It is odorless, an especially desirable feature in connection with kitchen ware and many types of packaging. It is already being used for toothbrush handles and similar molding applications.

Tests of the new material have shown a range of water absorption of from 1.0 to 1.7%. When exposed to an atmosphere of relative humidity of 90% until equilibrium was reached, an increase in length of only 0.4% was noted. Minimum molding temperature was given as 465 F, and the flow temperature as 322 F. Also of importance is the molding range. Tests made upon the cellulose propionate samples showed good parts produced over a range of 80 F.

Physical properties announced included:

	min.	max.	typical
Rockwell Hardness (R scale)	63	104	97
Specific Gravity	1.17	1.22	1.19
Distortion under heat (Cent.)	49	66	52
Water Absorption (24 hrs. immers.)	1.0%	1.7%	1.4%
Elongation	25%	43%	35%
Tensile Strength	2800 p.s.i.	6000 p.s.i.	4070 p.s.i.
Impact Strength (Izod) per in. of notch	0.8 ft. lb.	11.4 ft. lb.	7.8 ft. lb.
Dielectric Constant (1 megacycle)	3.3	3.5	——

Better ethyl celluloses were developed during the war in connection with the proximity fuse, a secret component of certain of the army's later rockets. Higher impact strength over a wide range of temperatures was achieved, and these improvements are now available to industry.

The cellulose ester plastics are still restricted in their expansion by the situation which arose during the war. While the molding industry was permitted to increase its capacity by adding new presses, there was little increase in production of materials. Present supplies are therefore inadequate, and there is little chance of an entirely satisfactory situation in 1946. Present capacity is about 65,000,000 lb., while estimated capacity of new construction should raise this to about 90,000,000 lb. by the end of 1946.

An official of a leading producer of cellulose plastics has estimated that the various industries will take these materials in about the following percentages: Automotive industry, 15%; continuous extrusions, trim, etc., 15%; toothbrush handles, 8%; combs, 6%; telephones, 6%; toys, 4%; novelties, 13%; miscellaneous industrial items, such as goggles, respirators, etc., 24%; cosmetic containers, 4%; radios, 3%; refrigerator parts, 2%.

Another basically new material is polyethylene, offered under the name Polythene. It was developed specifically to meet the military need for a high frequency insulating material in connection with radar apparatus. Maintaining flexibility and toughness over a wide range of temperatures, it has already gone into peacetime use in packaging, for battery containers, etc. It is the lightest of all the commercial plastics.

Some representative physical properties are:

Specific Gravity	0.92
Tensile Strength	1800-3000 p.s.i.
Elongation	50%
Water Absorption (24 hrs. immers.)	0.01%
Dielectric Constant (1 megacycle)	2.3

Allyl chloride, also a new arrival, possesses interesting properties in that it has the characteristics of the thermosetting plastics combined with high transparency.

Polystyrenes Improved

The polystyrenes have been improved in a number of ways, including better mold release in a new series of Styrons, better finishing, better welding and higher weld strengths. Their field of application has been extended by the use of contact pressure laminates. Several new hydrocarbon or nitrogen copolymers, having higher heat distortion points, made their appearance. Cerex and Styramic HT are trade names for materials of this group.

Properties of Styron 411 have been given as:

Water Absorption	less than 0.05%
Specific Gravity	1.054
Tensile Strength	5,000 - 9,000 p.s.i.
Impact Strength (in lb. per in. of notch)	0.3 - 0.5 p.s.i.
Rockwell Hardness (superficial 15x)	89 - 92
Elongation	1.5 - 3.5%
Heat Distortion	170 - 175 F

For the new heat-resisting polystyrenes:

Cerex

Heat Resistance	to 230 F
Dielectric Strength	excellent
Tensile Strength	good
Impact Strength	good

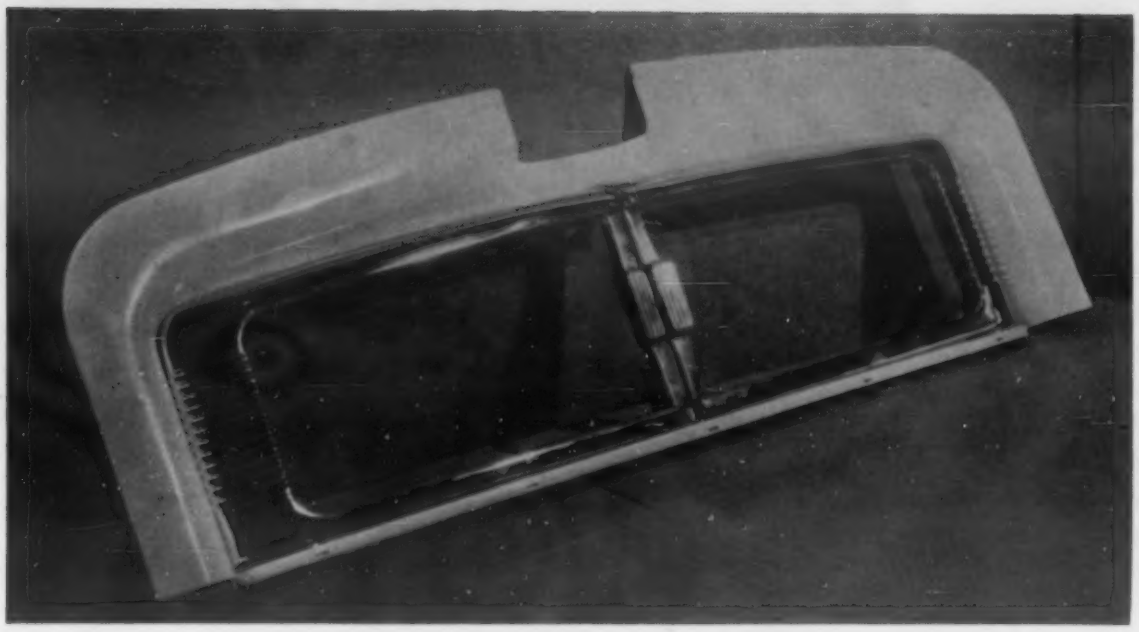
Styramic

Heat Resistance	to 184 - 187 F
Dielectric Strength	excellent
Tensile Strength	good
Impact Strength	good

Styramic HT

Heat Resistance	to 236 F
Dielectric Strength	excellent
Tensile Strength	good
Impact Strength	good

Insulation for navy cable, and various coating and film applications were the wartime uses for plastics of the vinyl group. They have found wide acceptance for civilian production for washable upholstery, rain-



Plastics continue to be used for functional as well as decorative purposes, both of which requirements are filled by these Lustron refrigerator parts.

coats, shoe soles and uppers, unbreakable phonograph records, printing plates, and many other articles. Formulations for industry are frequently copolymers, as vinyl chloride acetate, vinyl chloride butyral, etc. A recent development was the preparation of suspension or dispersion types for coatings.

Nylon, familiar as an extruded filament, was produced as a powder for molding. Combs, slide fasteners, and tableware will be produced with this material. Nylon-bristled toothbrushes may have a nylon molded handle also. Nylon-bristled paint brushes scored a success during the war, and are ready to repeat in the civilian economy. Nylon filaments have also invaded the cordage field, producing ropes of exceptional strength.

A mica-filled phenolic-type material having very low electrical loss characteristics has been developed for radio components, such as coil forms and relay parts. Melamine-base grades have also shown improvements, such as the production of rag-filled materials of high impact strength. One of these melamine-formaldehyde types, with chopped cotton filler, has been adopted for a washing machine agitator to replace one of aluminum.

A melamine-formaldehyde resin made with asbestos filler, and used during the war as an aircraft ignition material, has been taken up by several farm equipment manufacturers for tractor ignition systems. It serves as a dielectric with high resistance to flash-over and tracking when used with high-voltage, low-amperage currents.

Melamines have also gone into hot-setting glues, into various applications in the textile industry, and recently into the production of high wet strength papers for use in packaging applications, etc.

The search for lightweight, high strength structural materials for the wartime aircraft industry brought forth the foamed plastic, among many others. It was used in cellular cored laminates to provide self-supporting flooring in aircraft, and for other constructional items. These materials are now finding a place in refrigeration, in commercial aircraft, in prefabricated housing, and for office and home construction.

One of these foamed materials arousing interest of refrigeration engineers is cellular styrene. Tests have shown it to possess the lowest heat transmission values ever obtained. A phenolic resin has given promise in refrigeration also, ease of fabrication being one of the advantages offered. The phenolic has been poured into hollow walled spacing, then caused to foam by application of heat, providing a cellular insulation.

Use of glass fibers as a laminating material has produced plastics with strength values that definitely reach those of the metals. Such laminates were used for radomes and other parts in military aircraft. A felted asbestos paper laminate of high strength has also appeared in the market recently.

Large Section Plywoods

Developments in wood use have been largely in the fields of the improved woods, plywoods, or wood composites. High frequency heating of thermosetting resin glues for plywood bonding has permitted work with very thick sections. Panels as large as 12 in. thick, and 4 by 10 ft. in area, have been produced. Temperatures of 240 F have been reached in 10 min.

One of the newest developments in plywood is prefinishing. Mill finishing offers considerable advantages in cost over finishing on the job by hand labor, and by making possible uniform matching finishes should stimulate the use of plywood for panelled rooms, railway car interiors, etc.

A new material with interesting possibilities for high production fabricating is a wood veneer bonded to metal backing. Offered under the trade name Decorative Armorply, it can be stamped, drilled, or formed on ordinary metalworking machinery, using production line methods. The wood veneer may be of any type, and the metal backing may be steel, brass, aluminum, copper, etc., in a range of gages. The wood veneer offers the natural beauty of that material, while the metal backing provides formability, strength, and dimensional stability. It is favored for fire-resistant applications such as plane interiors and railway car interiors, and for office furniture, radiator covers, etc.

Other plywood developments have been the facing of the wood material with metal. Stainless steel, aluminum, and copper have been especially interesting and have found application for decorative interiors, store fronts, etc. New core materials have been used in special-purpose plywoods, such fillings including ethyl cellulose, balsa wood and cellular or corrugated materials. The laminates have gone into refrigerator installations, fire-retarding walls, plane flooring, and like applications.

Impregnated and compregnated woods are now standard materials of several years standing. The impregnation of wood with dimethylolurea, with pressure and warming, to increase its hardness, density, and moisture resistance has so far been utilized mostly in the manufacture of novelties and small items.

A new composite, offered under the name Tekwood, has been highly successful as a wartime container material and is finding wide use in civilian air freight and express. It is composed of a resin-bonded hardwood core and kraft paper facing, the composite possessing flexibility, light weight, and good strength. It is also used in automobile foundation panels, truck linings, house trailers, display signs, storage cabinets, movable partitions, toys, trunks, furniture, and the like.

Tests with Tekwood have given the following results:

	Tension tests
With grain	Ultimate stress (avg.) 10,210 p.s.i. Mod. of elast. (avg.) x10⁶ 1.283 p.s.i.
Across grain	Ultimate stress (avg.) 2,910 p.s.i. Mod. of elast. (avg.) x10⁶ 0.336 p.s.i.

Standard panel size, 48 in. by 96 in. Standard thicknesses 3/32 in. and ⅛ in.

Plywood panels may be faced with one of the densified and impregnated woods to produce a hard, glass-like surface in an all-wood sheet. Insurance companies have shown interest in this panel because of its fire-retardant properties.

Use of molded plywood sections was begun before the war, but the all-plywood plane stimulated and developed the forming techniques. Plywood boats and buildings required huge sections, and these methods are counted upon to produce the all-plywood prefabricated house in the future. Bridge and roof trusses made with laminated timbers have already been made to span 160 ft., and standard sized laminated timbers have been called an important future item in the lumber trade.

Last year the Great Northern Railway announced that it was building 1000 plywood boxcars. The first of these cars have been completed and put into service. Outside sheathing, side and end linings, and ceiling insulation are of plywood, with steel underframe, posts and braces, and steel dreadnaught ends and roof. Doors are of plywood. The cars are intended to be used for lumber, newsprint, and other high-class heavy commodities, and some possible weight saving was sacrificed in favor of ruggedness, but about 4000 lb. reduction was made in each car.

Synthetic Rubber

Because of the extreme shortage of natural rubber, developments in that industry were almost entirely developments with synthetic rubber. Advantage has been taken of the properties in which the synthetics excel natural rubber, particularly abrasion resistance, and resistance to deterioration by oil, chemicals, sunlight, and heat. Conveyor belts to handle work at elevated temperatures, hose to handle oil and gasoline, packing in pumps handling corrosive chemicals, and many similar uses have been found for the synthetics.

A. L. Viles, president of the Rubber Manufacturers Association, stated last October that synthetic rubber has now permanently established itself as a new basic world raw material. Authorities in the rubber field had previously given the opinion that, to maintain its place as a basic material under peacetime conditions, synthetic rubber must show superiority in one of the two fields offering large tonnage consumption —automobile tires or tire tubes. Mr. Viles announced that, because of its exceptional capacity for retaining air, butyl rubber was our number one tube material.

A second development of long-range import was the announcement that synthetic rubber had been used to produce a crepe rubber shoe sole, formerly produced only from crude natural rubber. Synthetic crepe rubber was more durable and tougher than the crepe from crude rubber, it was stated, and could be produced in a variety of colors.

Foamed rubber products are important materials in construction of upholstery for automobiles, busses, railway coaches, and passenger planes. It was recently announced that a 50% synthetic and 50% natural rubber latex will go on the market for the preparation of such rubber articles. It will be superior to any straight synthetic foam rubber. During the war, when natural rubber was in critical supply, Buna-S had been used for the preparation of the all-synthetic material. It is the consensus of opinion that 100%

natural rubber latex still produces the best foam rubber items.

A new development in tractors makes use of the excellent physical properties of rubber and steel used together. Airport tractors are being constructed with steel reinforced rubber belts for the tractive element, the belt having rubber cleats to provide traction in difficult going. A similar unit has already been produced for farm tractors.

Several new polymers have been added to the list of synthetics, notably a chlorostyrene, a modified GR-S type. Early laboratory reports are impressive, but the material has not yet been released to industry.

The synthetics have been most successful in the specialties fields, where their superior properties can be exploited to full advantage. Molded rubber items, pipe linings, rubber soles and heels, vibration dampeners, and pipe coupling rings have been well received by industry. The substitution of Hycar for natural rubber as the bonding agent in abrasive wheels was recently announced.

An interesting product for which an increasing number of peacetime uses has been found is conductive rubber. By addition of carbon black and other ingredients to rubber, the material, ordinarily an insulator, becomes a conductor of electricity and radiates heat. This property is of importance in the explosives industry, where the dissipation of static charges reduces the spark hazard. The material has performed similarly in hospital operating room equipment, where explosive concentrations of ether fumes may accumulate. Shoe soles made of conductive rubber have been used for workers in industries where the explosion risk exists.

Glass and Glass Fibers

Achievements in glass technology have included the production of much industrial equipment, such as centrifugal pumps for the chemical industry and Godet wheels for the rayon industry. Applications of glass fibers, both as batts and as woven fabrics, have been of especial interest to industry, the glass batts becoming thermal insulating material or electrical insulation, while the most striking use of the fabric has been as a laminating base for plastics.

A new process for fabrication of glass parts has been developed, and given recognition under the name multiforming. It consists of molding a glass frit similarly to the forming of metal powders, and of subsequently sintering the formed part. The method is of particular value when metal inserts must be used in a glass part, since the sintering temperatures do not cause the stresses that would result from attempting to embed the metal in molten glass.

Techniques for soldering glass have been greatly improved, a result of wartime needs for huge quantities of high-grade vacuum tubes for radio, radar, and other electronic work. Durable metal-to-glass bonds can now be made with ordinary solder and a soldering iron after the glass surface has been properly prepared.

Announcement was made of a new type of glass, highly resistant to hydrofluoric acid. The new glass is a phosphoric oxide type, and has been used successfully for safety goggles where protection against hydrofluoric acid fumes or spray is needed, as well as for other uses in contact with that acid.

One of the most exciting announcements of the year was the release of information about the development and properties of a new class of materials called the silicones. Chemically of an organo-silicon nature, they offered a combination of some of the properties of plastics with the higher heat resistance of silicon. Most of the types possessed upper temperature limits in the neighborhood of 500-600 F. They found immediate use in connection with glass fiber or asbestos insulation for electric motors, where an increase in the safe working temperatures can be translated into higher power ratings.

Resistance to deterioration at elevated temperatures, electrical insulating qualities, water resistance, and, in certain liquids and greases, good lubricating properties made the silicones versatile materials. In addition to serving as insulating varnishes, they became lubricants for motors running at elevated temperatures, waterproofing materials for ceramics, and the basis for high temperature paints. Rubbery varieties were formed into gaskets for aircraft turbosuperchargers, while liquids showing the unusual property of relatively constant viscosity over wide temperature ranges were used in aircraft instruments. All types are inert chemically, and so find use as packing or lubricants in chemical machinery.

Of the ceramics, the newer types such as the steatites received increased recognition for use where tolerances must be held closely. The steatites, magnesium silicates, show only about one-fourth the shrinkage upon firing that is characteristic of other moldable ceramics, and so can be formed with smaller allowances and held more closely to size. They have won a place as insulators and for refractory uses.

Just as the improved woods have won back some of the ground lost by lumber as a structural material, so new processes are putting wood fiber products into the structural field. Laminated paper, impregnated with plastics, has been used in the aircraft industry for partitions, droppable fuel tanks, and other parts. It possesses very high tensile strength, a smooth surface that requires no special finish, is resistant to moisture, to scratching or denting, to corrosion by salt water or salt air, and does not splinter when broken. It can be molded to desired shapes on equipment now used for forming plywood, and at similar temperatures and pressures. It has already been used experimentally for wing tips, wing ribs, and control surfaces for aircraft. Use in bus and truck panels, railway car partitions, etc., is indicated.

Parts and Metal-Forms

Reviewed by Fred P. Peters

CONSEQUENTLY information on the specific advantages, limitations and applicabilities of the various types of parts is now widely disseminated and applied and metal-forms once only vaguely understood are becoming production and design commonplaces. In place of a simple half-dozen or so types of parts (castings, die castings, stampings, forgings, machined parts, tubular forms) available to the engineer of 20 years ago, today's production planner finds these subdivided and added to, to give him about 20 commonly available types of parts or production methods he can use.

In 1945 the competition among these part-types for the engineer's favor revealed continuing and increasing interest in those forms that tended to circumvent machining and in the use of parts that could be made completely or purchased to final shape and size. This meant that those part-types that feature intricacy of shape and/or close dimensional accuracy (e.g. precision "lost wax" castings, die castings, plaster mold castings, plastics-moldings, brazed stampings, etc.) received a large share of attention. A subsidiary movement was noted toward improving those precision metal-forms that have been traditionally higher in cost or slower in production rates than others (e.g. precision castings and spinnings) so as to make them more competitive for mass-production.

All of which adds up to this outstanding trend for 1945-1946 in the application-engineering of the various types of parts: There is a tremendous wave of interest in "lost wax" castings and a similar but smaller swell toward the other accurate casting methods—die, permanent-mold, centrifugal and plaster-mold castings. Among the other forms, extrusions have made considerable, occasionally spectacular gains, and the continually increasing use of assembled structures (weldments and brazed stampings) has also been worthy of note.

Other interesting trends include the settling-down of powder metallurgy into its best fields of application, a healthy symbol of progress for this fabrication method; the growing use of parts made from tubing; the development of large forgings, especially in the light metals; the success of post-formed laminated plastics for various types of products; and general progress in the use of injection molded plastics.

Precision, Castings, Die Castings, etc.

Precision castings made by the "lost wax" method have attracted the most widespread attention of all the metal-forms. Their wartime use for turbine buckets or blades and other intricate and precise parts that had to be made of refractory and unmachinable alloys for gas turbines, jet engines and turbosuperchargers received much publicity. Of course the war's end brought an abatement in demand for such parts and for the large output of ordnance, electronic and machine parts made by this process, and many shops have reconverted to their normal piece time production of dental and jewelry parts. But a recent phenomenon in this field is the influx of new manufacturers, who have never made precision castings for other than industrial or war products, and these are aggressively exploring new industrial applications for such parts.

Among the latter very new uses that are certain to be of future importance are precision cast molds or dies for die castings, plastics and rubber. In these cases the number of parts required may be relatively small, while the high accuracy and intricacy required (especially when the dies must be made of hard materials) pose a very real manufacturing problem, which precision casting simply solves. Related to this use is the development of precision cast milling cutters; a large auto builder successfully made and used 10,000 precision cast milling cutters which required no finishing except a sharpening of the cutting edge.

At least two large industrial manufacturers are now interested in the precision casting of Alnico magnets. The process is expected to cut an even deeper dent in the stainless steel field than it has already. Meehanite precision castings have been made experimentally and tested, and may find application for a few specialized purposes.

One manufacturer is establishing his precision castings setup on a truly mass-production scale, and has already taken the method out of the small-lot range. Through new investment materials [see the article in this issue on "Melting and Casting"] finer reproduction and more accurate dimensions can now be achieved.

Typical of what was done during the year with precision castings is this story from a manufacturer of business machines. A certain cam normally required 59 machining operations, with some dimensions held as close as 0.001 in., others to 0.0025 in. The operations-time, material and spoilage on the job added up to a cost of $7.00 per piece by machining. But by converting the part to a precision casting, the total cost per cam dropped to $1.25, with quality and accuracy satisfactory in every respect.

Castings of Other Types

Die castings began to recapture their curtailed markets midway in the war, after X-ray inspection of die castings was standardized and the Army and Navy

finally accepted the long-known fact that such castings were not necessarily or characteristically unsound. During 1945 they moved ahead rapidly as reconversion began and as the high-pressure methods of making die castings with excellent mechanical properties attained wider use.

An interesting and idea-full recent development is the production of die castings with close fitting threads, either male or female, instead of making the parts (e.g. nuts for electronic equipment) by machining, including tapping or chasing the threads. The threaded die castings, made in zinc alloy, were less expensive and more satisfactory than were their predecessors made on screw machines. The die for casting the parts included a threaded core in each cavity; after the castings are solidified all the cores on one gate are unscrewed automatically as part of the die-casting-machine's operation, and no ejector-pin marks are left on the part.

Developments in centrifugal castings are reviewed in the "Melting and Casting" article in this issue; the considerable progress in plaster-mold castings and in permanent-mold castings were assayed in our October and April 1945 issues, respectively.

1945 saw the culmination of the wartime trend to replace steel forgings with steel castings or malleable castings wherever possible because of the often desperate shortage of forging capacity. In many instances the castings have been less expensive and have performed so satisfactorily that their users are now definitely "castings-minded" toward future designs. A few aircraft builders used steel castings of "aircraft quality" with outstanding success as part of their airframe assemblies. Composite welded structures, often embodying castings, forgings and plate material in the same structure, have also added to the use and design-possibilities of castings.

Steel castings in particular emerged from the war in a much stronger position than before. They are now available in several hard-to-forge alloys, including high-carbon and copper-bearing steels. Liquid quenching practice and published work on the hardenability of cast steel have carried steel castings into really heavy-duty applications.

Forgings

On the other hand forgings have been improved in quality, versatility and general applicability. One down-to-earth study of forged vs. centrifugally-cast steel cylinder barrels showed that forgings have better longitudinal tensile properties and inferior transverse properties, with the average about equal. A new type of part was suggested—a "cast forging," whereby steel forging blanks are cast close to final die size and shape, and then finished in a die-forging hammer.

Forgings with exceptionally good properties and economy are also being made by a combination of hammer-forging and press-forging. Thus one-piece controllable-pitch aircraft propellers were produced by hammer forging the part with the side arms minus cavities, then extruding out the holes in the side arms with a press-forging operation; material-savings were 25 to 30% and weight-saving 75 to 125 lbs. per forging using this combined method.

An outstanding late-in-the-war application of forgings was the use in the Buick Hellcat (the M-18 tank destroyer) of forged steel track links in place of steel castings, formerly employed. The earlier M-4 tracks with cast steel links had weighed 7,000 lbs. each; the M-18 tracks each weighed 3,000, primarily because the extra strength and soundness of the forgings permitted them to be much smaller in size and therefore also to require smaller accessory track components. Each of these link forgings had an integral lug that rides in the center of the track and (with the other lugs) guides the track and keeps it from coming off at high speeds and in fast maneuvering. The root of this critical lug must therefore be strong and tough, and it is a tribute to forgings that they so ably filled this requirement.

Aluminum and magnesium forgings continued to get bigger in physical size. The forged aluminum aero engine cylinder head program received wide publicity and suggested to many the possibilities in combining the lightness of aluminum with the strength of forgings. Forgings of R303 aluminum alloy (tensile strength: 85,000 p.s.i.) made on a 12,000 lb. hammer were displayed, and were called the largest "super-strength" aluminum alloy forgings yet made; as a matter of fact the use of R303, 75S and other high-strength aluminum alloys has generally been considered impractical.

Magnesium forgings made on presses up to 18,000-ton capacities were planned during the past year but are still commercially in the future. A combination of press-blocking and hammer-finishing has been found very successful for magnesium forgings, and permits the production of large forgings with presses of relatively low capacity. The technique of forging a cast *blank*, previously mentioned with respect to steel, is also being studied on magnesium. Recent progress in magnesium forgings has been such that forgings longer than 4 ft. and weighing nearly 20 lbs. can now be had.

Weldments and Brazed Assemblies

The use of welded products in place of cast, forged or riveted has been one of the outstanding trends of recent years, and 1945 was no exception. After engineering attention to the crackups of welded ships had shown that not welding but (a) *bad* welding and (b) unsound design were at fault weldments quickly regained the prestige they had lost and moved on to conquer new fields. The story of the welded aluminum ponton bridges presented in our November 1945 issue demonstrated the production speed and design-

lightness coupled with complete safety that good welding can permit.

Various types of heavy machinery were fabricated by welding in recent months. A powder metallurgy press for friction materials was welded from heavy steel plate. Sheet metal forming presses of another manufacturer, formerly made with cast steel crowns, beds and slides, were produced by making those components of welded steel plates. A large machine tool manufacturer, although still using cast bases, has converted his guards and covers, gear boxes and the like to weldments.

A bomber nose-frame, formerly a magnesium casting, was successfully redesigned as a steel weldment to weigh no more than the magnesium part and to be otherwise more satisfactory. And welded alloy steel locomotive boilers, though higher in cost, were reported to be easier to maintain, more efficient thermally and lighter in weight than riveted steel boilers.

Among all the wartime developments in brazing sub-assemblies to give a complex, strong and precise product, few attracted as much interest as the 1945 announcement of an automobile manufacturer that his 4-cylinder engine would be made up largely of brazed parts. The engine (bare of accessories) weighs 58 lbs.; the cylinder block is composed of light-wall alloy steel tubing for the cylinders and cam-follower guides and sheet steel stampings for the heads, ports, valve cases and water jackets. There are 120 copper-brazed pieces in the entire cylinder block.

Stampings, Drawn Parts, Extrusions

Cold-formed, stamped and drawn parts as well as those hot-pressed from sheet had established their material-saving and machine-saving propensities during the critical conservation period of the war. In recent months they have benefited from wartime experience with them (e.g. the brazed automobile engine described above is a literal profusion of stampings). Sheet and plate up to ¾ in. thick can now be cold-formed, and progress has been made in the production of such large and intricate parts as automotive rear axle housings by pressing.

Naturally the more ductile materials have been preferred, but with carefully worked-out processing steps, high-strength steels, stainless steels and stainless-clad steels have been readily formed and drawn by experienced stampers. The new super-strong aluminum alloys are more difficult to form than the older types but stamped and drawn shapes are available in them, with only a few restrictions as to bend radius, sheet thickness, depth of draw, etc. Remarkable progress in deep drawing heavy magnesium sheet (i.e. in the neighborhood of 0.5 in. thick) at elevated temperatures was described during the year, so that magnesium pressings more than 1 ft. long and over 10 in. in diameter are now available.

Parts made from special-shaped extrusions are giving increasing competition to castings, screw-machined products and forgings. In years past extrusions for such use were chiefly available in lead, copper and brass, and to a small extent aluminum and magnesium, but recent developments have extended the field to include aluminum bronzes, zinc alloys and steel. Magnesium extrusions have reached the stature of a major metal-form.

Aluminum "stepped" extrusions attracted especially wide attention in 1945. Stepped extrusions provide a stepped-series of pre-determined cross-sectional sizes along the length of the bar and are especially attractive for the production of long tapered products or those with sharp changes in cross-section. Extruded shapes for structural use of course found wide use in aircraft manufacture and architectural designers are already using them imaginatively for trim, moldings, frames as well as for structural components of new buildings now on the drawing boards.

Impact extrusions, especially in aluminum, are currently the beneficiary of a minor boom in interest and use. Such parts are cup-shaped, often with thick bottoms and thin sides, and can now be produced as shells up to 10 in. long and about 5 in diameter. The process has been intensively developed so that production rates are fairly high, tolerances good, finish excellent and costs—for parts of suitable size and shape—attractively low.

Tubular Products

Parts or products made from tubing are similar in many respects to those made from extruded bar—indeed much seamless tubing is actually extruded. Pierced-and-drawn, welded, welded-and-drawn, and brazed tubing are other types useful in the manufacture of both large and small parts.

The advantages of tubing as the raw material for parts ranging from long cylinders to flat or thick annular discs sliced from tubing seem to have been rediscovered in the past year or so. The increasing use of welding and brazing have greatly aided tubing, for the combination makes possible the production of intricate parts that could not be economically produced by any other means.

The cause has also been helped along by the recent development of special types of tubular raw materials. Tool steel tubing is discussed in the "Steels and Irons" article in this issue. Atomic-hydrogen welded stainless steel tubing is a new product with interesting possibilities. Ultra-thin tubing, in various diameters and with walls from 0.0001 to 0.001 in. thick, is now available in copper, nickel, gold, silver, stainless steel and other metals for electronic, fine instrument, medical and other uses.

Copper alloy tubing of various new types has recently entered the market, both for chemical and mechanical applications. Bi-metallic tubes, in which two different materials (e.g. admiralty metal and

steel, or a copper-base alloy and aluminum, or two copper-base alloys) are drawn together to give a duplex tube with one metal on the inside and the other on the outside, have special uses in the process and marine industries. Continuously-cast 88-10-2 bushing stock (virtually free of segregation) and continuously cast phosphor bronze tubing are other important recent developments in the copper alloy tubing field.

Powder Metallurgy Parts

Although parts made by sintering and pressing metal powders have entered few new fields of application during the past year, they have expanded their use in established fields and their competitive qualities have been enhanced through improved production techniques. Porous metal filters made by powder metallurgy methods turned out to be one of the top contributors to Victory in the war; aluminum bearings, new types of iron powder pole pieces and cores, and high density, high-strength iron machine parts were other notable application developments.

Iron-and-carbon powder compacts that can be heat treated to tensile strengths above 100,000 p.s.i. are a recent development intended to overcome one of the most serious limitations of powder metal products—their relatively low mechanical quality. "Hard-faced" iron powder parts, in which soft, highly pressable iron powders are made into parts with an ultra-hard material sintered onto their surface, is another step in the same direction.

Powder metallurgy came into wide use in 1945 for the production of commutator pole pieces, some of them of extremely complicated shape. Pole pieces with one or more curved faces and rotors with several step-like projections have been made from pure carbon-free iron powders at the rate of over 1 ton per day. No machining other than a few minor finishing operations is required.

Iron powder cores for electronic applications, too, are replacing conventional laminated cores not only because of their spacial efficiency but also because of their versatility and production advantages. Plastic components may be molded along with the iron core; the cores may be made as sheets, rods or tubes, with or without inserts; and close electrical and mechanical tolerances can readily be held by powder metallurgy methods.

The use of electrical contacts made from metal powders continues to increase; one company now manufactures them in 20 different powder metallurgy materials, for applications ranging from low-voltage, milli-ampere service to the largest circuit breakers for high-tension lines. Contacts made from graded multiple-layers, in which gradations of hardness and conductivity are provided from one end of the contact element to the other, are a recently developed powder metallurgy product.

Sintered beryllium for X-ray tube windows is a development of recent months. Ordinary vacuum-cast windows were reported to show a tendency to crack during brazing onto the glass-sealing element, and rolled titanium-bearing beryllium was claimed to be deficient in X-ray transparency. The beryllium windows produced from sintered beryllium powder are said to overcome these drawbacks and to be ductile, less susceptible to cracking during brazing than vacuum-cast windows and more transparent than titanium-bearing beryllium.

An interesting though highly specialized new product involving metal powders is the "static eliminator," used to eliminate static on telegraph tape and to make plastic powders lie down in dies. It consists principally of radium sulphate rolled into gold powder, which is subsequently flattened into a sheet and brazed to a silver disc.

Other Types of Parts

One of the currently fastest comers among part-production methods is broaching. Once a very-high-production-volume specialty, this method has now reached down and proved its value for moderate-volume jobs. Typical performance records also show superlative precision, often down to ±0.0002 in.

Space will not permit detailed description here of recent progress in applying parts made by spinning, plastics molding, plastics sheet forming, screw-machine methods, etc., but the interested reader will find them discussed in the reviewing articles in this issue on "Stamping and Pressworking" (for spinning) and on "Nonmetallic Materials" (for the plastics).

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Among the new coatings and finishes are the silicones fluids which are water repellent. On such parts as this surface resistivity is little changed after days of immersion in water. (Courtesy: Dow Corning)

Coatings and Finishes

Reviewed by Kenneth Rose

KEEN COMPETITION has been promised for postwar markets, and manufacturers throughout the country have been preparing to meet that competition by improving their products in every way. One of the most obvious ways is to make them more attractive or more durable. In achieving either or both of these purposes, a prime consideration is the use of coatings or finishes of various kinds.

Durable coatings were devised during the war to give increased life to equipment under the severest conditions. Some of these have been adapted to current production during the year. In other cases the large-scale use of standard finishing procedures has brought the development of new and better methods of application, which again will affect the industry through lowering costs or improving the finish.

In a number of cases manufacturers are calling upon processes developed before the war, but never utilized by industry to the extent warranted because of the ban upon production of civilian goods. This is particularly true of some of the attractive electroplated finishes now being used to enhance the appeal of consumer goods.

In viewing the broad picture of developments in coatings and finishes during the past year, several features stand out. One is the increased use of phosphate or oxide treatments for finishing metal parts in both consumer items and industrial equipment. The value of these processes for preventing corrosion of parts for which applied coatings such as paint would be unsuitable was proved during the war, and the phosphating, blackening, and bluing treatments have been firmly established for widespread use in peacetime industry.

Pointing up the trend toward mechanization is the growing use of such devices as roller coating, silk screen stenciling, conveyorized coating of all kinds. While many finishing processes do not lend themselves to continuous automatic production, there is a strong drive to such type of finishing wherever it can be achieved.

Organic coatings have kept pace with progress in other types of finishing. Before the war various "trick" finishes had been developed, based upon the wrinkle paints and lacquers and the crackle and crystal finishes. In the first group tung oil, or a substitute for it, and the resin and other ingredients of the finish material are so balanced that the coating, when baked, pulls into a ridged pattern. Crystal enamels also make use of tung oil, and the surface of small crystals is obtained by baking in a gaseous atmosphere. Crackle lacquers make use of several coats, so applied that the top coat shrinks and breaks into irregular cracks, exposing the coating underneath.

Electroplating activities brought forth a number of important new methods and improvements. Announcement was made of the Promat process, in which high amperage a.c. is superimposed upon the d.c. The process has been especially successful for producing high speed deposits of copper, with control of brightness. It is also available for zinc, cadmium, and bright nickel plating.

Successful electrodeposition of metals on aluminum was achieved with the Alumon process. The metal plating of plastics marked another advance in the bonding of metals to difficult base materials. Advances in coating techniques were responsible for progress in the soldering of metal to glass to such a point that the joining could be accomplished with an ordinary soldering iron and the common solders.

Electrodeposited Plastics

Another step forward in electrodeposition was announced during the year, but has not as yet been applied industrially. This was the electrodeposition of plastics from dispersions, similar to the electrodeposition of rubber. The use of water dispersions of plastics for the coating of cloth has already become a commercial success.

In wood finishing, the use of alkyd lacquers for sealing the pores in the material in radio cabinets and similar articles, called tropicalization during the war, has been looked upon as a means of preparing American products for South American and other foreign markets. The process provides protection during ocean transportation. Clear coatings of improved film resistance, such as the alkyds, ureas, and phenolics, have already begun a comeback into postwar markets. These synthetics are satisfactory for close-grained woods. Baking types can now be dried in one hr. at 150 F.

Reproductions of fine grains by color plates made from photographs of beautiful and unusual wood samples offers a low-cost means of providing an attractive finish for the less widely used woods.

Metal coatings sprayed onto other metals and nonmetallics are of increasing importance.

Use of chromium plating for other than decorative purposes has become general during the war speed-up. In salvage operations wearing surfaces a few thousandths undersize have been built up by chromium plating. In production tooling, cutting tools intended for work with hard metals and abrasive plastics have been given added life by chromium-plating the cutting edges. Use of porous chromium plate for friction surfaces, in which ability to hold a lubricant is a determining factor, has increased considerably since its value was demonstrated by results with chromium plated engine pistons.

A feature of finishing activities as applied particularly to consumer items is the use of color. When aluminum is the base metal, the dyed anodized films produced by the Alumilite process have been very effective. The process has been used in industry for the production of such items as manufacturer's name plates or instruction panels. Electrodeposited films in color have been prepared by carefully controlled plating, and these have been popular in art ware. Enamels, paints, and lacquers, of course, offer an almost unlimited range of colors.

A recent development that has been successful has been the use of the Anozinc treatment over galvanized refrigerator parts. The Pro-Seal process is similarly used. The result is a clear bright metallic surface resembling the tin-plated parts used before the tin shortage made a substitution necessary. Formation of the white corrosion products associated with ordinary galvanizing is prevented. The process is used with cadmium plating also. An advantage of the Anozinc treatment, which consists of electrolyzing the work in a chromate bath, is that the film is tough enough to permit handling the work while it is still wet.

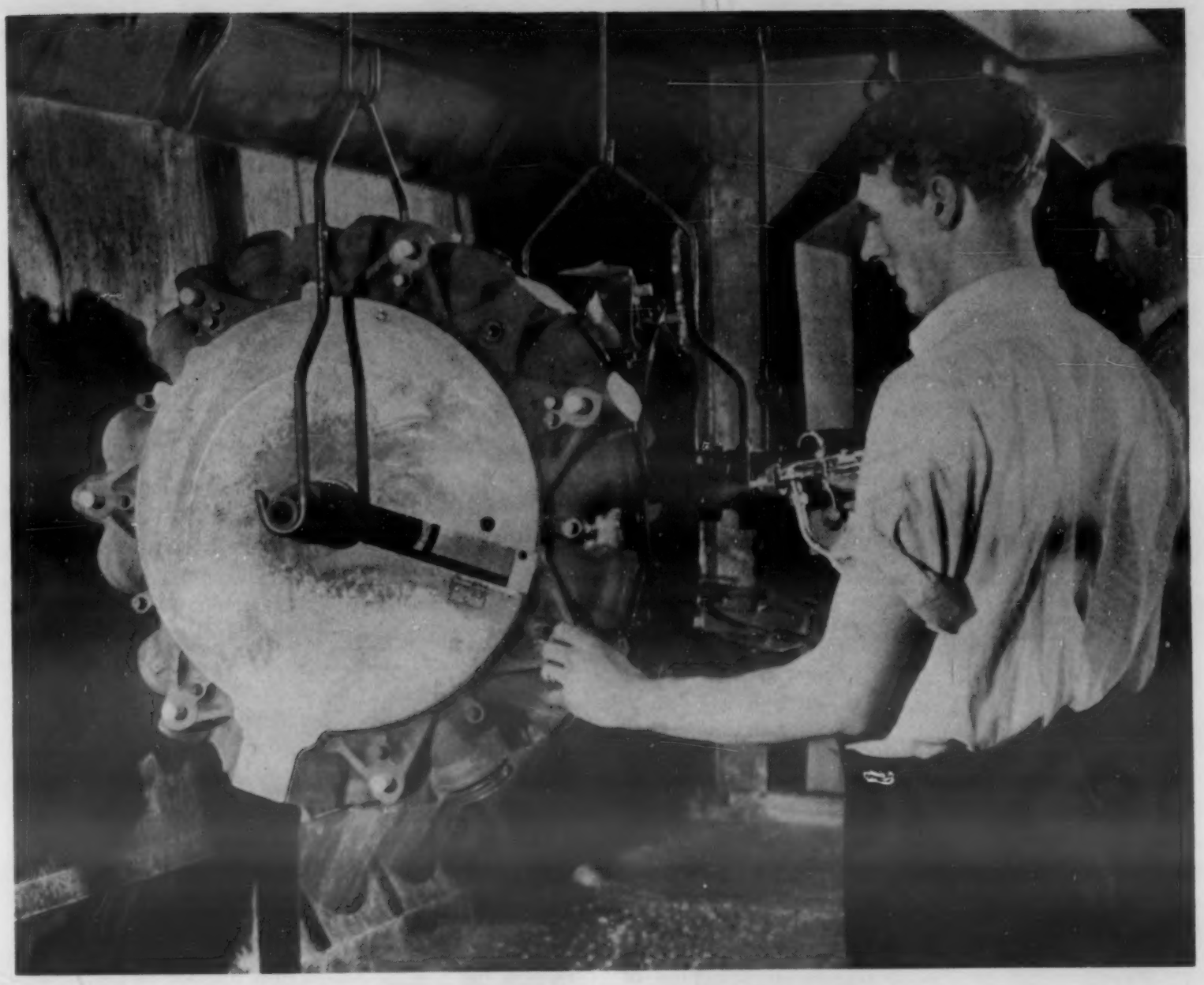
Similar resistance to formation of white corrosion products is imparted by the Iridite Galvon treatment, a simple dip at room temperature. The coating may be dyed various colors.

The Cronak treatment, also used to confer added corrosion resistance upon zinc, zinc alloy, or zinc plated parts, has been used to protect galvanized gasoline drums carrying high octane gasoline. The zinc is chromatized under carefully controlled conditions.

Solder Coatings

For protection of steel, copper, and brass in the electronic industries, in such parts as condensers, cans, and similar parts, a coating of 50-50 solder is being used. A lead alloy coating for sheet steel has been developed, but has not as yet been widely utilized commercially.

The anodizing processes for aluminum and its alloys are of long standing and are well understood. The work is placed in an electrolyte, usually either chromic acid or sulphuric acid, and a current is passed, with the work as the anode. A film of essentially



There has been a decided trend toward the use of synthetic enamels to achieve faster drying times and finishes that do not sag or crack.

aluminum oxide is formed. The discovery that this film, particularly the one formed in the sulphuric acid bath, can be dyed any of a number of colors is the basis for the Alumilite process.

The film is highly corrosion resistant, has good resistance to abrasion, and has good dielectric qualities. Colors of the dyed films are as permanent as dyes chosen.

Zinc and cadmium coatings may be colored black, or olive drab if desired, in a one-dip bath. These processes include those sold under the names Iridite Olive Drab, Ebonol Z, or Unichrome Dip. Corrosion resistance is increased. The surface retains a high luster if the treatment is applied over polished metal. Only a few minutes is required, and the bath functions at room temperature. Wartime stainless steels frequently required a blackening treatment to eliminate reflection. While the blackening of a material such as stainless steel would seem to be a profitless procedure, the process has been of positive value in the coloring of bottoms of stainless cooking ware to increase heat absorption and to provide contrast in decorative applications.

Black nickel plating has increased in use also. It has frequently been found advantageous to apply a black finish to steel by a flash coat of black nickel, or by oxidized copper plate. Mention has already been made of the greatly increased use of the commercial blackening and bluing compounds, and of the use of the phosphate treatments such as Parkerizing and Bonderizing. The latter is maintaining its place in the canning industry as a base for lacquer for sanitary cans, and will probably continue to do so through most of 1946.

Blackening treatments are available for copper and brass also. They are chemical procedures long familiar, or slight modifications of these standard formulas. A process for producing yellows, blues, browns, or

Not all coating materials are permanent, as, for example, this moisture-excluding material for packaging. (Courtesy: Dow Chemical Co.)

blacks on brass or copper involves oxidation at low temperatures and can be applied to steel by first brass plating the ferrous metal.

Vari-Color Plating

Two electroplating processes for producing highly decorative finishes on metals are being adopted for a wide variety of consumer products. They are Electrocolor, a process whereby a controlled thickness of copper deposit is used to give a very wide range of colors, and Patternplate, an electrodeposited film in which treated cuprous oxide, acting as a rectifier, is ruptured by passing current the reverse direction. A crystal finish results.

In the Electrocolor process the color is obtained by differences in refraction through an extremely thin film of copper and entirely without the aid of dyes or other organic agents. A coat of lacquer is required to protect the finish. It can be applied over practically any base metal, although for lead alloys, steel, aluminum, or zinc base alloys an intermediary coat of copper or nickel is required.

In conjunction with the color platings the variety of plating textures obtainable with Patternplate may be used to give spangle, crackle, or crystal effects. A lacquer coat serves for protection. Use of stopoff lacquers in connection with any of the plating procedures holds out possibilities for endless variation in colors, finishes, plated metal contrasts.

Use of the enamels ranging all the way from the baked finishes to the vitrified enamels has been given impetus by the development of the various types of radiant heating equipment. Combined with electrostatic spraying, these installations have offered the possibility of greatly increased production. In addition to the baked enamels, finished at temperatures of the order of 300 F, there are the vitrified enamels, including the low temperature types fusing at about 1100-1200 F, and the high temperature varieties requiring about 1600 F for vitrification. The latter types are essentially ceramic-coated metal, with the high corrosion resistance and other qualities of such a combination.

A new baked organic coating was announced, with sufficient flexibility to prevent crazing with change in temperature. It is available in white only, and is being used for finishing metal cabinets and like products.

Thin Vitreous Coatings

Progress in the high temperature vitreous enamels has taken the form of improvements to permit application of thinner coats. Greater opacity is the chief advance. The thinner coats are less susceptible to damage. Thicknesses have been reduced from the 0.018 to 0.025 in. formerly employed to 0.012 to 0.014 in. Acid resisting enamels are available when service conditions require, and resistance against thermal shock can be obtained when needed.

The newer enamels provide better bonding to the base metal. It has been found that a flash of nickel over the steel improves bonding, probably due to the lessened oxidation of the base metal.

Quite recently it was announced that the dream of enamelers, a single-coat covering that would adhere to the base metal properly and also possess all the requisites of a finish coat, had been achieved. Although not a large-production method as yet, it may soon be expanded in volume. Success with the one-coat enamel, it was stated, required the proper enamel, the proper base metal and close control during application and firing.

An alternative to handwork has been offered in another branch of the finishing field with the expansion of the use of electropolishing methods. These have become important commercial procedures in handling stainless steel, for which a high polish is frequently desired. Hand polishing costs were high, especially when working with a metal as hard and tough as stainless steel.

The process can be used for controlled removal of metal in a sizing operation, or as a deburring process, especially where the burrs are located in an inaccessible position.

A development in the application of neoprene as a coating was announced in which the synthetic is used in liquid form. It may be dipped or flowed onto metals, plywood, or other structural material, or applied with a paintbrush or roller. The process is useful for the rapid development of corrosion resistant surfaces in pipe, tanks, pumps, and other equipment. The coatings are useful at temperatures from −50 to +250 F.

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Melting and Casting

Reviewed by Edwin F. Cone

IN THE EARLY PART of 1945, or until soon after V-E day, production of steel and most other metals was at fever heat. By the time V-J day arrived, output had slackened, but by late August and after, there was a marked decline in activity—in both the melting and casting of metals—due to reconversion.

Up to May 1, 1945, the calculated weekly production of the American steel industry, according to the American Iron and Steel Institute, was 1,686,350 net tons or 94% of capacity. This rate gradually fell until for the third quarter the calculated weekly output was down to 1,424,733 tons or 77.8% of capacity. Due to a coal strike in October these figures fell to 1,268,625 tons and 69.3%.

The total 1945 production of steel ingots and steel for castings is estimated at about 79,000,000 net tons as against the 1944 record total of 89,641,575 tons.

In other metals such as aluminum and magnesium, the falling off in production last year was precipitous. Soon after V-E day and again after V-J day, production of both these metals was curtailed. According to the American Bureau of Metal Statistics, 776,446 net tons of primary aluminum and 168,337 tons of magnesium were made in 1944, mostly in new plants financed or owned by the American Government.

Civilian demand by late 1945 for copper, lead and zinc was so insistent that operations continued on a large scale. In some cases domestic output was not enough to satisfy all demands so that other sources such as stockpiles had to be drawn upon.

Open-Hearth Steel

During the first 7 or 8 months of 1945 the managers of steel plants, particularly the open-hearth, were kept exceedingly busy in producing enough steel for war purposes and to meet all WPB directives.

One of the important developments of the last year in open-hearth practice has been the all-basic furnace. This is a furnace in which silica brick in certain parts such as side and end walls or the roof has been replaced with basic brick.

The principal incentives for substituting a basic roof for the present silica roof, according to one authority, are (1) increased speed for melting, (2) longer life of the furnace, (3) less silica in the slag, and (4) easier clean-out of slag pockets. The principal disadvantages of basic brick indicate that it will gradually be destroyed either through chemical attack by iron oxide or through peeling caused by the formation and crystallization of a liquid phase in the hot surface of the brick.

Another open-hearth authority points out that at least three or four companies have had more than average results from all-basic ends; that there is less wear and tear on the brick work, and that the less amount of slag is so friable it can be shoveled out of the slag pockets.

Improved methods of materials handling and furnace rebuilding have been developed during the past year, resulting in less operating delays and furnace outage time.

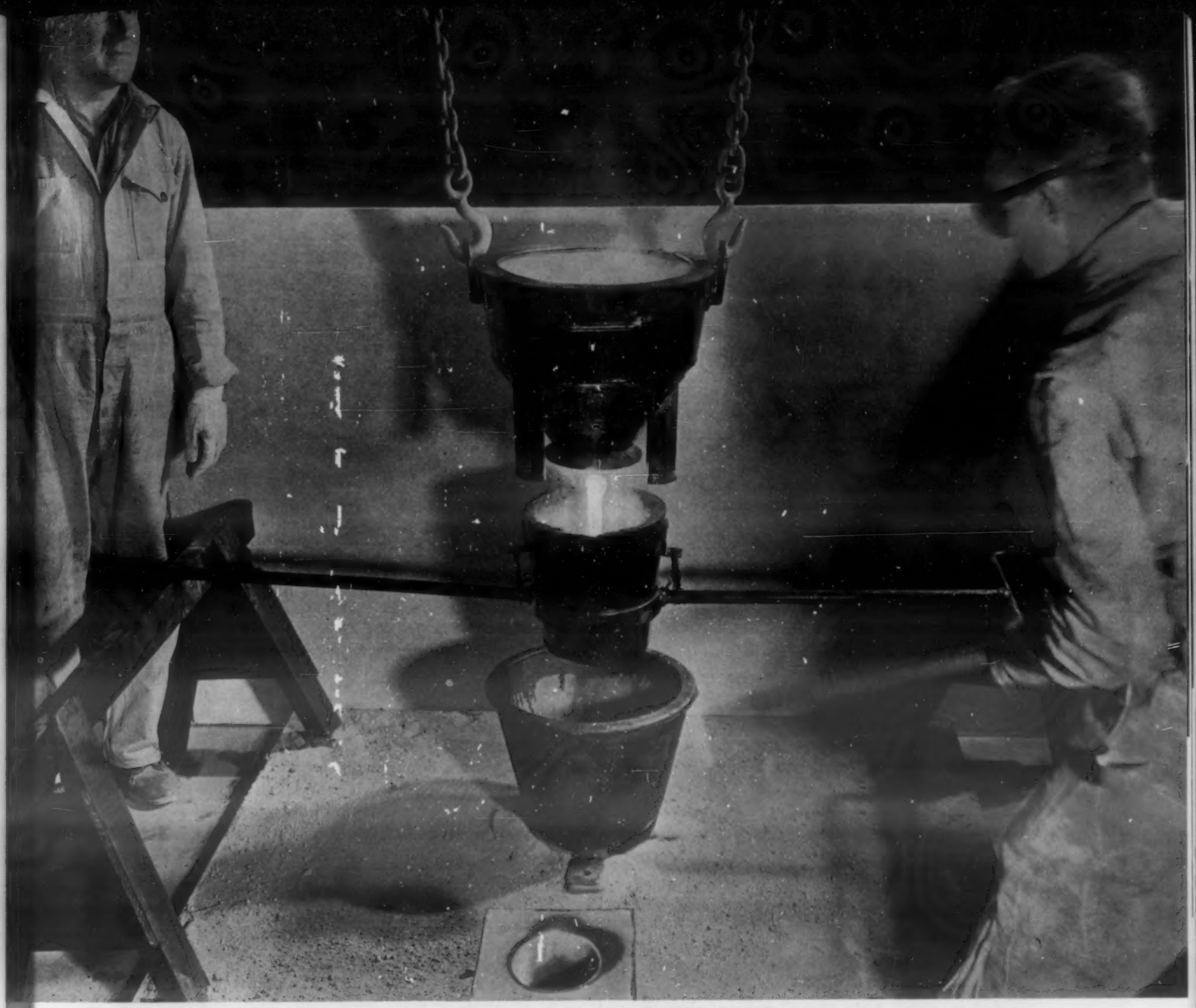
There has been during 1945 some intensive study of rammed bottoms with a tendency to their continued use, often supplemented by a burned-in layer of sintered magnesite.

Attention has also been given recently to the use of preparetl ores for charging such as sinter, nodules and briquettes, permitting the use of higher pig iron charges or the use of high pig charges without the difficulties attendant on the use of many normal charge ores.

The use of flame radiation intensity measurements has been tried, permitting an improved method of determining the efficiency of furnace operation and design. Analytical methods have been extended at many plants with very satisfactory results.

The problem of sufficient scrap iron and steel of the right analyses continues to vex the industry. This is of supreme importance in most open-hearth departments because alloy contamination has been and is "very serious."

There was less decline in the open-hearth than in the electric and Bessemer steel output as the year



A special type of thermit has been developed for producing clean steel for castings, where conventional steel melting facilities are not available.

progressed. In the first quarter the open-hearth production was 93.3% of capacity, in the second it had declined to 92.1% with a fall to 79.9% in the third quarter. During the coal strike in October, the output was 72.3% of capacity.

Electric Steel

In operating technique used to produce electric steel, considerable profitable experience resulted from the study and operation of the five methods, beside the standard cold charge practice, currently used in making electric steel: (1) Bessemer blown converter metal refined in electric furnaces; (2) Bessemer blown converter metal partially refined in the open-hearth and finished in the electric; (3) metal from a tilting open-hearth furnace finished in an electric; (4) turnings briquetted, loose or crushed melted in a cupola and refined in an electric furnace; (5) cupola metal blown in a Bessemer converter and then finish refined in an electric. Definite progress was made in perfecting and improving these methods.

During 1945 there were many important installations of new regulating equipment, but most of this had been developed prior to last year.

One of the latest developments and one of no little importance has been the problem of the cost of electric steel. There has been, since the war ended, a desperate effort on the part of those in a position to do so to bring electric steel costs into a competitive

area with open-hearth. This was to be expected in view of the large volume of new electric capacity that was installed in recent war years. There is nothing definite regarding the progress in the solution of this problem—there really has been little time. It is felt by some, however, that the future of the electric steel industry depends largely on a solution of this problem.

Foundry Practice: Iron and Steel Castings

Most branches of the foundry and allied industries were busy with war orders early in 1945 but some were quite severely handicapped by lack of manpower —particularly gray iron and malleable companies. With the cessation of hostilities these conditions relaxed.

While operating at war capacity most producers of castings had no opportunity for developing new ideas or techniques so that very little time was left for initiating new ideas after the war's end. The following are some of the reported developments last year.

In the steel castings field the important developments were in application (see the article on Parts and Metal-Forms in this issue) rather than in the production of steel castings during 1945. A decided slump in production took place last year, particularly after V-J day, but it was on the way before that. In the early days of the war, steel castings were in very heavy demand, says one authority "but there seemed to be no place in the war effort for gray iron and malleable iron castings. As a result many of the producers of the latter converted to the production of steel castings."

There has been a complete reversal of this condition in the last year with orders for gray iron and malleable iron castings putting a strain on capacity, and demand for steel castings dropping off quite decidedly. One result of this trend has been that some of the smaller producers, particularly those making electric steel, have converted partially to the production of electric furnace gray iron.

During 1945 the Steel Founders' Society of America published a number of bulletins on research work which the Society is sponsoring. The most valuable ones are two covering a study of necked-down risers, and the properties of core oils with tests therefor.

A substantial amount of information on the properties of carbon and alloy steel castings at subatmospheric temperatures (as low as −185 F) was obtained last year. On a number of the low-alloy steels the values obtained indicate that cast steels are to be preferred as engineering materials for equipment operating at low temperatures.

Hardenability of cast steel was studied last year involving considerable research. The correlation and comparison of cast steels with wrought steels of similar composition was undertaken. Greater understanding of the hardenability bands and requirements was obtained and results show that the hardenability bands obtained can be used interchangeably between wrought and cast steels.

An understanding of the critical dimensions of necked-down risers has been reached by research during 1945 resulting in progress in the operating phase of the industry. The production of high quality castings is claimed benefited with operating costs in the cleaning room reduced.

During the last year core oils and binders have been compared to develop acceptance tests of these important raw materials. One of the reasons for making such studies was the interest that has been taken by the industry to establish procedures of quality control throughout the manufacturing cycle. It is believed, says one authority, that the control of this quality of the supplies will go a long way toward establishing quality-control procedures in the industry.

A notable trend was apparent in the gray iron foundry industry last year—one toward the partial or complete mechanization of the plants. The object of this has been to reduce the labor involved in some of the more arduous and disagreeable tasks usually present. These mechanizations included handling of overhead sand, the use of vibrator screens for shakeout purposes, the development of more modern molding machines, and other similar devices. There has been also a definite demand by the foundries for better pattern equipment from their customers.

A lot more interest has been taken by the gray iron foundries as a whole in the improvement of working conditions involving locker and wash-room facilities and in the general overall appearance of the foundry itself. The use of light-colored paints has appeared as well as the habit of the more methodical cleaning of windows and of keeping gangways free from unused equipment.

A decided improvement in the production and man-hours per ton of castings is expected to result from these changes—there were some indications of this during the latter part of the year. Another result that is logically expected is the ability to make it easier for the foundries to secure desirable labor.

One observer, close to the gray iron foundry industry, calls attention to the large number of employees of the foundry industry as a whole who are keeping currently up-to-date on the technical progress of the industry through membership in the industry's technical association—the American Foundrymen's Association. Membership in this organization reached an all-time high last year—in excess of 8,000.

The same observer states that he has been impressed "with the top-side directive placed on the Naval Research Laboratories at Anacostia, Md. to develop fundamental knowledge in gray iron." He recalls that the U. S. Navy made important contributions to steel foundry practice and it is expected that the results of the work on gray iron will be equally important.

Demand for gray iron castings for war purposes in 1945 was heavy until the war ended, but the foundries

were handicapped by lack of labor. As peacetime conditions began to prevail, demand continued more than normal and conditions eased.

Developments in the malleable iron castings industry during the past year were largely dictated by the industrial situation involving a great demand for tonnage and a scarcity of labor. One result of this situation has been the adoption of continued mechanization and the introduction of duplexing melting in order to make a continuous supply of metal available.

Last year many of the larger production malleable foundries completed or extended their installations of continuous molding, pouring and casting equipment. The smaller plants and those larger ones whose type of production is not well adapted to continuous conveyor operation have also made improvements in methods and equipment.

Use has been made of tractor-mounted or bridge cranes for yard handling of raw materials; power lift trucks have been employed for materials handling within the plant; molten metal handling equipment has been installed and heavy work in general has been substantially reduced. All this has improved both production and working conditions. Such trends may continue into the future if the present demands of labor for short hours, easy work and high pay continue.

There has been a decided interest in the inverted Bell type annealing furnace. Involved here have been efforts to anneal in a perfectly controlled atmosphere. Generally this control is intended to avoid scaling of castings. It is quite possible when working in this direction to choose gases in which annealing is not as rapid as in some others and affect quality by minimizing decarburization.

The war shortage of manpower has continued and has resulted in the industry's operating at substantially less than the maximum capacity, justified by demand for the product. A program has been adopted of training returning veterans and new employees which, it is believed, will prove effective in increasing operations.

Non-Ferrous Melting and Casting

In the melting and casting of aluminum and its alloys there were several significant developments during 1945. Among these may be briefly mentioned the following:

An increased use of synthetic sands has developed. In the past most foundries used so-called natural sands, probably because synthetic materials were not available and also because very little was known about them. A smoother casting has been in demand since the war ended. By the introduction of suitable binding materials it is possible to obtain sands with better strength and permeability which naturally produces sounder castings. Synthetic sands permit freer escape of gases from the mold.

There has been an improvement in refractories for melting furnaces. Various types of firebrick such as zircon are now available, which do not react as readily with molten aluminum as do the older type refractories. With the ordinary alumina-silica brick the repeated melting of aluminum results in some of the alumina from the metal going into the firebrick and in turn some of the silica from the brick going into the molten metal, increasing the silicon content of the metal and decreasing the silicon in the firebrick. This results in a deterioration in the quality of the firebrick and in metal of inferior quality.

A better understanding of the minor alloying additions to aluminum alloys has been developed. There is also an increased interest in alloys that can be produced from scrap metal. An authority points out that while these two things may sound independent of each other, actually they are both part of a broad knowledge that has recently been brought to light regarding the use of metal of low quality. This increased knowledge has broadened the base of alloys that can be developed from scrap. He cites the alloys 319 and 333 of the Aluminum Company of America as typical of such alloys.

During 1945 the commercial production of aluminum bearings was started, although preliminary development work was initiated before the war, with small experimental lots being made in 1939. Two special alloys for these were developed by aluminum manufacturers—750 and XA 750. These aluminum bearings are made as permanent mold castings and then subjected to a special pressing operation. They have been developed primarily for use as connecting rod and crankshaft main bearing inserts for heavy duty internal combustion engines. Some of their characteristics are claimed to be: Long bearing life, ability to withstand high bearing pressures, resistance to corrosion, no bearing surface to wear through, etc.

Process Types: Centrifugal Castings

So rapid was the development of centrifugal castings and of casting technique during the war that a decided lull has characterized operations the past year. Foundries have been turning their attention to other than implements of war. Many of them have been making a study of how the centrifugal casting process will fit into their post-war operations.

Authorities in this field believe that the impetus given centrifugal casting of steel during the early war years led to a crystallizing of the rules of good practice. Many parts not really suited to centrifugal casting have reverted to the static methods while cylindrical and other suitably shaped parts have become more firmly entrenched in the centrifugal foundry. The idea is becoming established that the centrifuging methods for odd shaped parts offer little if any advantage over good static practice, but with

the true centrifugal methods all the advantages of centrifugal casting accrue.

According to one authority "tubes, cylinders and sleeves are most economically cast centrifugally. In steel tubes, castings cannot compete economically with the usual types of rolled tubing, but in special types of tubes centrifugally cast tubing is often the economical answer." Last year centrifugally cast tubes up to 16 ft. long were made in carbon steel where the wall thickness is too great for economical piercing and rolling, in low alloy steels where special combinations are required, and in heat resisting alloys which are difficult to roll or forge. The latter is pointed to as a particularly promising field for centrifugal cast tubing.

Another promising idea, which is being tried for alloys which are difficult to pierce, is centrifugally cast hollow billets for forging or rolling into tubes.

In cast iron, pressure pipe were made almost exclusively by centrifugal processes. Last year also witnessed trends toward the centrifugal casting of such parts as cylinder liners, rolls, bearings and axles. The liners are usually cast in spinning metal molds resulting in a casting of unusually fine grain and with a high degree of uniformity.

Last year mold materials for irons and brasses in some instances were being changed to graphite, assuring a very smooth surface with a mold material that will not burn in.

Die Casting

Progress in die casting non-ferrous alloys may appear slight on a year-to-year basis, but it is not inappreciable. During 1945 certain trends have been observable. Conversion to peace-time needs has brought an enormous demand for more die castings, some of these in remarkably large sizes and in thinner sections than were once considered feasible in castings so large.

Shops making casting dies have been swamped with orders since the war. So many old dies have been put back into service that many, if not most, established casters have had to turn away many new customers because they found it difficult to care for the pressing demands of old customers.

For zinc alloys especially there has been a trend toward making casting machines run automatically and some unattended, except for filling with metal, all events in the cycle being precisely timed. This helps to keep machines operating at full capacity and speed, and to lower the cost per casting.

Some experiments in making dies of lower cost, especially for short-run items, are in progress but this work is not yet far enough advanced to indicate the degree of success attainable.

There has been a considerable change in the average composition of aluminum alloys since the war began. Today the higher silicon alloys are favored, especially for hard-to-cast shapes, since silicon increases fluidity. As the S.C. 7 A.S.T.M. alloy is low in cost and can be made from secondary metal, it promises to become popular as a general purpose metal. But the G2 alloy, containing 8% magnesium, has the highest impact strength and gives superior results in anodizing. By the use of cold chamber machines, iron content in aluminum alloys can be kept below the 2% max. in most specifications and is often held to 1.3% max. for high-grade castings.

Some progress has been made lately in die casting brass alloys but rapid die deterioration is still a problem and cost per casting remains higher than for any alloy save the little-used tin alloys. In consequence brass is now rarely used except when maximum strength, special types of corrosion resistance or maximum stability are essential.

Alloys based on tin and on lead are still relatively inactive in die casting. Applications are chiefly those requiring special types of corrosion resistance or, for lead, maximum density as in X-ray machine parts.

Precision Casting

Precision ("lost wax") casting continued to make most of the headlines given over to close-tolerance casting processes. The outstanding developments in precision casting practice were the use of castable synthetic resins in place of wax for the fusible pattern, the application of low-melting bismuth alloys for the molds in which the fusible patterns are cast and the increasing use of a new investment material. Some new casting machines were also introduced.

The use of plastic patterns in place of wax is said to increase the dimensional accuracy of the overall job and to provide a more stable pattern material, permitting better maintenance of shape and accuracy throughout the numerous stages of handling by hand and on machines.

The investment molding material recently applied is ethyl silicate and is said to provide a heat resistant mold and exceptional surface quality.

Among the interesting new machines now generally available is a high speed, precision-controlled centrifugal unit in which the metal is melted in a carbon monoxide atmosphere in a closed cylindrical electric melting furnace.

A phenomenon all its own is the growth of this field in the past four years, even including a number of newcomers in 1945. But there has appeared an appreciable abatement in demand, and the volume of precision castings production in peacetime will not reach the wartime peak for a long while. Parts for gas turbines continue to be made and the industry has largely reconverted to jewelry and dental products.

No little attention, however, is being given to new industrial applications, among them molds for die castings, plastics and rubber products. There is definite prospect also of important commercial production of stainless steel precision castings.

In spinning metals there has been considerable progress in the shaping of all commonly used metals. This 6-ft. spinning is to be the end of a stainless steel tank.

Forging and Pressforming

Reviewed by T. C. Du Mond

WE ALL KNOW that the hot and cold working of metals in the fields of forging, stamping and pressworking has progressed enormously during the war. It is still too early to tell just what effect all of the war-found knowledge will have on peacetime industry, but it is safe to predict that when production gets back to normal there will have been a lively jockeying for leadership between forgings and stampings, forgings and castings and between the combined forging and stamping fields and other methods of producing metal parts such as casting.

No comparable figures are available for forging, but the Pressed Metal Institute estimates that on a tonnage basis there have been more stamped and drawn products made during the last two years than in the previous eight years. A similar story probably could be told for forgings because of the large number of parts, such as cylinder heads, that were once castings but are now made as press forgings. In fact there were so many forgings in the famed Flying Fortress that it was often facetiously called the Flying Forging.

One reason for the lack of a clear picture as to what effect new knowledge will have on the future is that thus far there has been little new production. Such a situation is especially true in the stamping industry where most stamping and drawing is done in job shops. Too, production has been so great on old products and by past methods that until the present rush is past there will be little opportunity to apply newest methods to old established products.

In answer to the question: "What do you consider to be the most significant development in forming metals?" one executive stated that he felt that the most important change in the fields covered by this term was in the knowledge of the men engaged in it and of the men buying such products. While this is generally true, there has been a vast change in equipment. The changes are not basic, but they have widened the scope of metal forming considerably.

Hydraulic and mechanical stamping and forging presses are now made in capacities that equal all but the largest steam hammers. Heating has improved so that less metal is lost through scale and so forging shops are cleaner and healthier than they once were. Knowledge of die design and metal flow has been gained that permits forging and stamping to unheard of tolerances. Control of presses and hammers is so precise that—as has been demonstrated—a walnut can be cracked on a large press without smashing the nut meat.

Forging

This country has emerged from war with a vastly greater capacity for producing forgings of all kinds. When war production first got under way almost every piece of ordnance equipment was produced from forgings whether this was the most suitable method or not. Therefore, all possible pressure was exerted to have hammers, presses, upsetters and other types of forging machines come pouring from the builders plants into arsenals, forge shops and individual plants.

It is certain that with all of this equipment available every effort will be made to keep it busy. Thus there is bound to be continued progress in the technology of forging if efforts to keep equipment in operation are successful.

Naturally enough, most of the advancement in forging has come in the use of closed dies, regardless of whether the actual forging operation be by hammer, mechanical press or hydraulic press.

Perhaps most of the improvement along the above mentioned lines can be best illustrated by one outstanding example on which information has just been made available.

Finished forging of crankshafts complete with counterbalance and cranks in correct relative position is being done on a production basis with a 4000-ton forging press with only two strokes of the press.

Through application of developments made during the later part of the war, industry is now producing forgings with as little as 0.0156 in. without additional sizing and coining operations. Such accuracies in forging will eliminate many machining operations and speed machining in cases where automatic equipment can be employed.

Higher production rates and lower machining cost offset the extra cost of forgings held to close tolerances. Better equipment, improved die construction and improvement in hot die steel are the contributing factors which make this new type of forging possible.

Forging of high strength ferrous and non-ferrous alloys have brought out many new developments in forging practice, especially in aluminum alloys for aircraft and in metals used for shell production. Forging presses are gaining considerably more recognition because of their ability to produce forgings of high accuracy at a fast rate. Proponents of press forging equipment feel that the proper flow of material to give a fibre structure of maximum strength can be better controlled in presses because of the build-up of internal pressure. Proper die design and preparatory blocking operatings have permitted the production of high strength and quality forgings in presses that could not otherwise have been made.

Perhaps not typical, but at least illustrative of ingenuity in speeding up forging operations is the case of a small forging being produced on a 200-ton press. The shuttling of the upper die on alternate strokes performs two hot forging operations without the work being moved in or from the lower die. Two strokes of the press complete the forging.

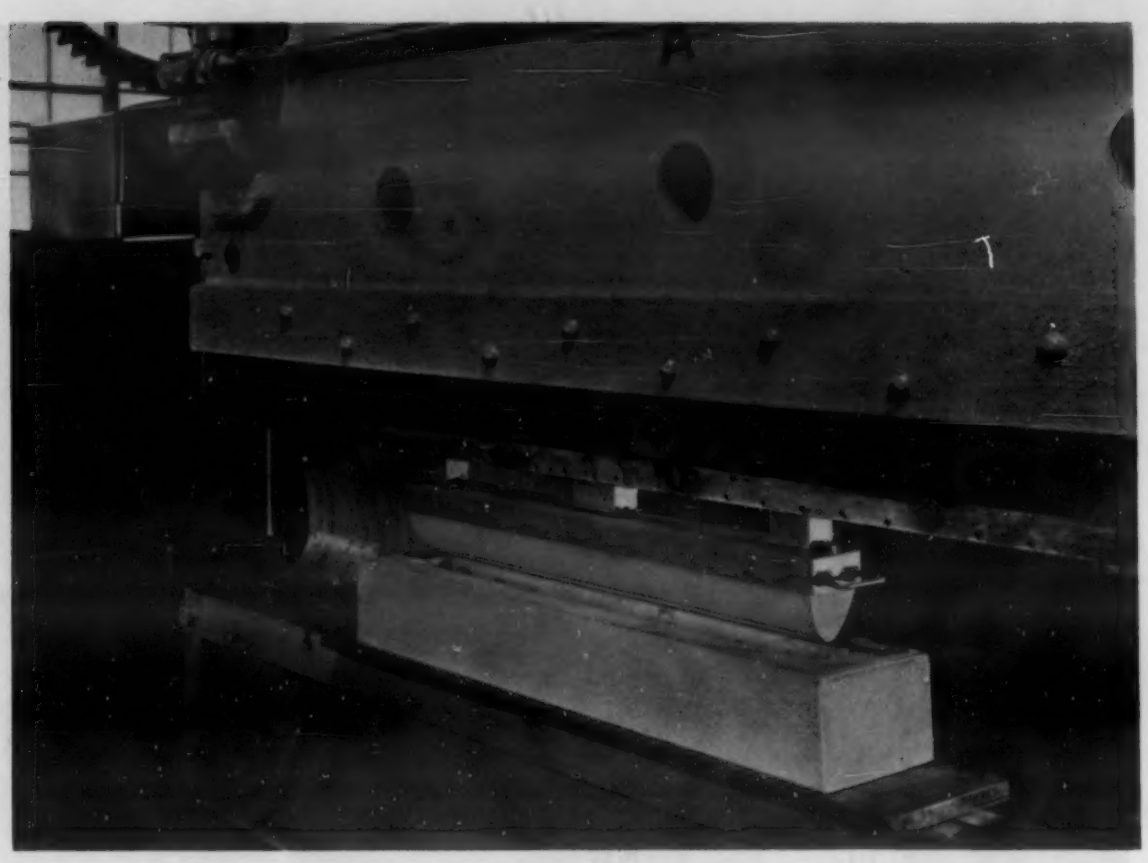
Considerably more power and higher speeds are now available in both mechanical and hydraulic forging presses. For comparative purposes, here are the figures on mechanical forging presses. At the start of the war machines of this type were comparable in capacity to 5000-lb. steam hammers. At the close of the war there were many mechanical forging presses with capacities approximately equal to 8000-lb. steam hammers. Now there is under construction a mechanical forging press which will compare in capacity with a 12,000-lb. steam hammer. This huge press will weigh 1,300,000 lb.

World War II subjected military equipment to all kinds of conditions, many of which imposed unpredictable and previously unencountered loads and strains. Observation of the many phenomena of metallic structures operating under these conditions taught many more men, many more things about all metal structures and about forgings in particular.

Five years ago engineers writing design specifications, in most cases, were almost completely ignorant on the subject of forgings. Now many can and do write exacting specifications for forgings, indicating a thorough knowledge of materials commercially forgeable, properties obtainable, tolerances possible, surface qualities, effect of various requirements on costs and similar factors.

With vast changes in the types of materials being forged and the varieties of metals in each broad group both forgers and users of forgings have had to become more familiar with the working characteristics of materials. Some metals can be forged anywhere within a rather wide band of temperatures, on others forging can be started at a high temperature and continued until the material becomes relatively cool, still others must be forged at almost an exact temperature, with frequent reheating if more than a few blows of the hammer or strokes of the press are necessary.

Because of the fussiness of the metals being worked, especially aluminum, magnesium and stainless steel, heating furnaces have been made more precise and provided with greater heating ranges. Protective atmospheres are now being used extensively and many forge shops have installed induction heaters to bring



Cast resins have found an important place in metalworking as dies for forming operations such as that being performed in this brake. (Courtesy: Durez Plastics & Chemicals, Inc.)

metals to temperature quickly and surely. Surface protection of metals is of increased importance now that forgings are made close to size and final shape.

Forging is now overcoming some of the old traditions and superstitions that prevented its keeping pace with other forming methods. That the field will continue to progress is certain due to pressure from within the forging industry and from competition by other forming methods.

Pressforming, Stamping, etc.

Probably no field of metal shaping of comparable age has progressed so rapidly during the war years as pressforming. Accuracies once thought impossible are now commonplace; speeds once thought the ultimate are now considered slow. Too, and this is perhaps the most important advancement to the greatest number of people, pressed shapes can now be made in small quantities with reasonable economy.

Aircraft and armament share credit for advancing pressforming techniques. The aircraft field sponsored and pushed the use of soft dies and stretchforming. Armament demands gave stampers an opportunity to show that stampings could serve to make parts once made exclusively of forgings.

In making stampings of some of the newer metals, stampers have had to forget all they ever knew about the more common and harder metals. Magnesium presented one of the biggest problems because of the need for using both heated dies and heated blanks. Incidentally, now that war production has stopped there has not been the anticipated drop in magnesium stampings. On the contrary, one of the leading stampers specializing in magnesium reports that he will need more capacity to handle the production of magnesium stampings for consumer goods.

Stainless steel has caused many a stamper deep concern and more than one sleepless night. Difficulties with stainless were centered chiefly in problems concerning rather complicated shapes, although deep drawing was also troublesome.

One aircraft parts manufacturer has developed a patented technique for forming complicated shapes out of 18:8 stainless that seems to overcome most of the difficulties formerly encountered. These troubles center about overthinning of the material and wrinkling.

The new technique which works so well on stainless, briefly, is this: Staging dies—as many as are necessary—are produced from the final die by making a beeswax-cheesecloth lamination formed by hand in the die by unfolding the final form to the stage, or stages, desired and then making a reinforced plaster die, backed with clay.

Development of the process came not only because of production difficulties of the material but also to eliminate if possible the fabrication of many small sections and then joining them by welding. The latter goal was desirable both from a production standpoint and end use requirements where it was important to eliminate differential temperature stresses which affect, particularly, unthickened metal adjacent to the weld.

With the use of soft die materials, it is now practical to use pressforming methods to produce comparatively small lots of drawn shapes. (Photo: Free-Lance Photographers Guild)

In normal practice it has been the habit to use metal in a gage at least 1½ times the net thickness to allow for thinning. With this process it has been possible to keep thinning down to 10 to 15%. Some sections previously stamped from 0.078-in. stock are now produced from 0.063-in. stock and still maintaining specified net thickness of 0.050 in.

While stamping of 18:8 stainless led to this development, experiments with the forming of difficult shapes in aluminum and alclad lead to the belief that most sheet metals can be so formed.

The methods of producing stampings from soft, easily made die materials such as wood, rubber, plastic, wood compositions, zinc alloys, lead and others are probably most important to immediate postwar needs. The use of such die materials will continue to be of importance to those industries where considerable use of sheet metal forms is necessary, but where quantities of individual parts may run from one to a few thousand.

The importance to normal production can be realized when it is known that soft dies were used to form the bodies for all test and showroom models of two leading makes of automobiles. Permanent dies will be made from the temporary if the designs are considered satisfactory. If changes are necessary, altera-

tions can be made in the temporary dies before they are copied for permanent dies.

It has been estimated that over 90% of dies used for the huge flying boats are made of soft materials. A fabricator of custom-made station wagon bodies plans to use so-called temporary dies for his entire production, saving 83.33% on die costs.

Experimentation is being conducted into the use of oil or water in place of the rubber blanket used in a variation of the Guerin process of sheet metal forming. Indications are that the liquids will result in greater accuracy and will permit the forming of more complicated shapes. The material being formed is first forced against the water and then additional water is forced in the cavity to buildup even greater pressure.

The designers and builders of stamping and forming equipment have kept apace and in some instances ahead of the trends. They have provided presses with larger power units for higher speed production. It has been proved that there is no limit to the speed of drawing, contrary to a rather general belief that metal can only be drawn so fast. Hydraulic presses are especially suited to high speed production because of the control possible over speeds at any stage of the forming cycle.

Huge stampings, such as auto body tops, formerly could only be made on mechanical presses, now hydraulic presses large enough for this purpose are available.

In connection with the stamping of turret tops for automobiles it is interesting to note that these large units are now being drawn in reverse position from past practice. The highly finished part is up in the die and therefore less subject to scratching when being removed from the die and press.

Presses are being called upon to do other tasks than mere forming now. For instance, one press has a cycle of 3 hr., 20 min. The work is tubular steel that comes to the press hot and already formed. During the long cycle, the press performs a finish forming operation and then acts as a holding fixture while the parts are precision brazed and cooled. The press cycle, completely automatic, is: a press dwell at 200 tons for 1 hr., a pressure increase to 400 tons for 20 min., and finally, a reduction of pressure to 200 tons for a dwell of 2 hr.

Longer die life and more accurate stampings and deep drawn parts result from the use of carbide dies. Such dies were used but little prior to 1939, but during the war carbide dies became important to the high production of both steel and brass cartridge cases.

Knowledge gained during the war has led to the present use of carbide dies as large as 13½ in I. D. Products drawn on carbides have expanded greatly both as to variety of shapes and of metals drawn. Among metals drawn are plain carbon steels, special alloy steels, brass, aluminum alloys, copper, zinc alloys, tin and lead.

Results currently being obtained from carbide dies are illustrated by a company producing high pressure cylinders for gas storage. More than 4,000,000 distinct drawing operations are performed in a year on metals ranging in thickness from 0.040 to 0.440 in. to form containers as large as 8¼ in. dia. and 32 in. long. At least 95% of these operations are now done on carbide dies. Gains resulting from use of carbide rather than conventional dies include: 50% reduction in scrap; 25 to 30% increase in number of satisfactory pieces; almost complete elimination of surface defects in finished drawings. These results were obtained without change in fundamental die design, operation of presses or lubrication.

Spinning

Spinning of metals is an old art that has recently come to a new state of importance with a vigor that is bound to keep it going. Probably the aircraft industry gave the greatest impetus to the revitalization of spinning. Prior to the war most of us were familiar with spinnings such as those used for aluminum kitchen utensils.

With the increased use of magnesium during the past few years there has come development in spinning to form this material. Where shallow depths are involved, magnesium can be spun cold, but for most operations the material is heated. When hot, magnesium can be spun as easily as any other metal.

Among the metals being spun successfully in rather large quantities are the above mentioned magnesium, aluminum, alclad, low alloy steel, stainless and other high alloy steel, brass and copper. Most of these materials are worked cold, but in some instances heat is applied to make the materials more ductile.

Spinning of stainless steel is of considerable interest now for a variety of uses. One outstanding example of a spinning from stainless is the end of a milk storage tank liner. This part when finished has an outside diameter of 90½ in. This size is attained by welding together two semi-circular pieces of 304 stainless, grinding the weld smooth and then spinning.

One of the most recent advances in spinning is in expanding and reducing tubing made of any of the materials previously mentioned. In addition to these operations many circular parts requiring closed ends or partially closed ends can be produced by spinning, using the application of heat. In many cases, spinnings are being used where deep drawings were once employed.

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Rolling, Wire Drawing, Extruding

Reviewed by Harold A. Knight

IN THE FIELDS of rolling, wire drawing and extruding, most progress has been in the speed of the processes and accuracy of the finished products. For instance, a cold strip mill is said to roll difficult metals to accuracies varying from 0.0001 to 0.0003 in., and wire is being drawn to a diameter of 0.0001 in. Much activity has developed in extruding, especially with the high melting point metals and alloys, particularly nickel and copper. Too, there was announced recently (MATERIALS & METHODS, December 1945) the fact that zinc is now being extruded commercially.

Until V-E Day on May 8 faster and faster production was the chief goal of our war production program. Rolling mills kept pace with this program and seldom became a bottleneck. An increasing proportion of steel was the product of the cold strip mill where speed increased 8 fold in the past 12 yr., with indications that it has not yet reached its limit. In fact finishing speeds of 5000 f.p.m. have been attained in tandem cold reduction and temper rolling units with 6000 f.p.m. now under development. The efficient and practical use of these high speeds has required the use of large coils of hot rolled bands, built up of multiple lengths by welding, which has demanded improved welding technique to prevent breakage and roll marking in the rolling process.

Generally speaking, higher speeds, increased use of automatic controls, increased load factors, decreasing percentages of scrap and wider use of roller bearings featured rolling during the war months of 1945. There was also noticed a trend towards maximum flexibility in rolling mills. Provisions were made at a new mill at Homestead, Pa. for rolling, in addition to ordinary low carbon steel slabs, all grades of alloy and stainless steel, made by U. S. Steel Corp. Thus mills rolling slabs could serve equally well a 2-in. to a 20-in. slab, and in all analyses of steel.

High mill speeds have introduced the twin motor drive to cold reduction mills, a type previously confined to large relatively slow speed mills such as blooming, slabbing and plate mills. The demand for sensitive speed and tension control, the limitations of the conventional pinion stand and single motor drive to operate at high speeds from a gearing design standpoint, and the detrimental inertia effect of large rotating parts were paramount in this development.

Developments in electrolytic tin plating, reaching a peak in 1945, resulted in lines successfully operating at speeds up to 1250 f.p.m. This was envisioned as important at the outset if the cost were to be competitive with hot dip tin plate.

New hot strip mills under development were being designed for greater production by the use of heavier slab weights rather than by higher speeds. Specifications also call for lighter finished gages than were general, a requirement that has demanded several modifications to existing designs.

Pickling, the process between hot and cold rolling, has also seen new developments aimed at speeding up, improving the efficiency of, and reducing the cost of pickling of strip steel. Thus a new scale breaker to be located ahead of the convential continuous pickle line has been developed which will be important.

Development in the bar, merchant and rod mill field, though always toward increased production per unit, is more toward better quality of product with as much attention being paid to the semi-finished products due to their effect on the final product as to the design of the finishing mills.

Better bearings in 1945 added much to efficiency, roller bearings tending to displace the sleeve-type bearing, at least on the horizontal rolls. With roller bearings a dry, unlubricated bearing is not so fatal, whereas a dry sleeve bearing burns up and heat-cracks the roll necks. It was found that power savings with roller bearings were 10 to 20% and often fewer drafts were necessary. Fabric bearings proved their worth in many applications, efficient if one keeps dirt and scale out of them, and lubricated by clean water. Better seals on bearings tended to keep lubricant in and foreign matter out.

Improvements were accomplished during the year in roll manufacture, one important trend being to use more than one alloy in roll manufacture, a typical composition of the new steel rolls being nickel, chromium and molybdenum.

The year perhaps saw no radical change in mill design, but rather the practical application of two radical mills that had been devised experimentally previously—the Krause Mill and the Uni-Temper. Both depend a great deal on tension longitudinally as well as plain rolling action.

Krause Mill—In the Krause Mill the reduction power is transferred solely by tension in the strip. Contrary to convention, the work remains still while the rolls and pinch (caused by cam plates) are given the motion. The rolling head goes back and forth, taking short bites. A heavy reduction is taken in one pass—hence there is accomplished in one handling

what is done in several handlings by the older method. The rolls are forced into the plate by the two cam plates. The mill has considerable stiffness without a great mass of metal.

The year 1945 revealed that the Krause Mill is no longer in the experimental stage. Experts now say that it will reduce any metal which can be wrought cold—and to a high degree of elongation in one pass. It was first applied to rolling brass and copper strip. More recently rolling mill authorities have concluded that it will fit into the steel industry just as well. It can serve as supplementary equipment for large mills, being especially adapted to rolling small tonnages.

Uni-Temper Mill—The Uni-Temper Mill, though first put into operation in 1944, began to be appreciated and recognized in 1945 when its real possibilities began to unfold. It is a single stand unit based on stretching the strip uniformly while moving at high speeds. In the manufacture of most cold-reduced strip for tin plate, auto sheets, etc., an important step is temper rolling or skin rolling. Its purpose is to produce a flat strip of specified gage, hardness, or temper, drawability, etc. The temper rolling operation has been the most difficult and costly.

The Uni-Temper mill has eliminated some of the previous undesirable factors. It is essentially two 2-high mills built into the same housing. The extreme top and bottom rolls are idle, being driven by frictional contact with the strip only. The strip enters between the top pair of rolls and wraps around the No. 2 roll (second from top), then around the No. 3 roll and then through the bit of Nos. 3 and 4. By virtue of the strip wrapping around the driven rolls, they serve to act as tension multipliers as well as to roll the strip slightly.

Because of low pressures, cast iron instead of steel rolls can be used, lessening cost. As to power, 0.6 hp-hr. per ton is theoretically required as against 10-20 hp-hr. per ton for conventional temper mills. With the Uni-Temper mill, including uncoiling, reeling, drive and electrical losses, there is a power saving of ½ to ⅔. It is claimed that the product of the new mill reveals greater elongation or ductility for a given hardness than conventionally rolled tin plate. It has desirable "springback" characteristics. Even in early installations the average tonnage from the mill has reached 200 net tons per 8 hr. turn, using coils weighing 6000 lb. Contemplated improvements in coil handling, roll changing, etc., will speed this up.

Hand in hand with the improved mechanics of the Uni-Temper mill have been improvements in the electric speed controls of the mill. The speed relation between the two sets of mill rolls must be very accurate. Thus if a 5% elongation is to be made, the first set of rolls must run 5% slower than the second set, even at 3000 f.p.m. An electronic amplidyne system of control has kept these speeds meticulously correct and has enabled flexibility of operation. The drive represents the most intricate equipment built so far. There are 42 motors and generators in connection with the main drives, in addition to those used for auxiliaries. Undoubtedly this type of drive will have an important set-up in future temper mills.

A new and improved type of cold rolling mill, a 39-in. cluster type, will be installed in the newly-organized Washington Steel Corp., Washington, Pa. It will produce a more uniform strip with a higher strength-to-weight ratio. Stainless steel, cold-rolled by strip practice, is more uniform and with superior surface to sheets rolled individually. Flexing of rolls is eliminated by multiple-backing rolls and bearings within a solid housing. Thus equal pressure is exerted along the entire length of the work rolls, which function in an oil bath, filtered and cooled so that frictional heat is dissipated.

Very promising experiments on the use of the Sendzimir mill for rolling stainless steel are being conducted by the American Rolling Mill Co. and others. The mill is a precision cold strip mill with new and radical principles for steel, aluminum, copper and their alloys. The mill has no backing rolls, its work rolls are of smaller diameter than conventional and has deflection compensating features. Accuracy of 0.0001 to 0.0003 in. tolerance, depending on gage and metal, is claimed. Strip can be entirely parallel with edge tapers less than 3/16 in. wide. The resulting strip is free from camber and narrow widths can be economically produced by slitting, in addition to operating straight on winders. An annealed strip of medium gage has been reduced 70 to 85% in a single pass, resulting in a strip that is flat, smooth and accurate.

Wire Drawing

Though this article supposedly deals with 1945 developments in wire drawing, actually some were adopted in earlier war years but can be revealed for the first time now. It is trite to say that speed was the chief requisite in the wire producing program as in most other programs. This was accomplished in at least eight directions.

Thus equipment was built with larger motors, faster blocks and with better bearings; provision was made for more drafts—up to 18 or more on fine wire machines; dies were improved; better winding devices, as for spools, were evolved; there arose more efficient and foolproof straightening methods to "kill" the wire; there were better lubricants, particularly those with cooling capacities and those which do not break down under the high pressures met in modern wire dies; temperatures and lubricating properties of the draw compounds and dies are controlled better; in wet drawing pressure circulation of the solutions was used.

One 6-block continuous machine, with its air and water-cooled blocks and dies also cooled, can easily

turn out at least ten times more and better wire than the old slow-moving single block of pre-war. What might have been called trivia are now basic or fundamental. Thus to operate a modern multi-block high speed machine preparation of the surface before drawing must be perfect. Removal of scale by pickling must be 100%. The coating, or "go-between" as to lubricant and die, must be firmly adherent and of just the right thickness, for, if too heavy, it strips off; if too light, the wire scrapes and perhaps causes dies to "pull out."

As to dies, the carbides are kings of them all—carbides of tungsten, cobalt, boron, tantalum or titanium, or mixtures of the above. Of course in ultra fine wires the diamond die is still supreme. The manufacturer of new dies and reconditioner of used dies has introduced refinements in boring and shaping the dies. The bell (entrance angle), cone (die angle), bearing (straight part) and relief (exit angle) must be accurate, with finish and polish practically perfect. The old school of wire drawers peened and punched their own dies to suit themselves, with 0.002 to 0.005 in. tolerance between front and back of bundles good enough. Now for medium diameter wire ±0.001 in. tolerance is rarely exceeded, while for high grade fine wire, such as 0.010 in. carbon or stainless steel, ±0.002 in. is standard.

A development of the last year or two is the electric method of drilling diamond dies for fine wire, sponsored by the National Bureau of Standards. An electric spark is shot from the end of a platinum needle at the diamond while both are immersed in a chemical solution. The older method is with a diamond splint, with final polishing with a steel needle and diamond dust. While by the new method some excellent results have been achieved much investigation is needed to obtain uniform control, proper stone quality, etc. But experts believe it will have a major effect on diamond drilling and the wire drawing industry. Theoretically, one can foresee this as a quicker, cheaper and perhaps more accurate way of drilling diamonds.

Lime as an adjunct to wire drawing is slowly but surely being replaced by other cleaner and less wasteful media. New drawing compounds, both wet and dry are being compounded, often somewhat rust inhibiting and often giving good results. Molten salts for heat treatment are fighting hard to replace lead for patenting and other treatments. Some of the newer salt mixtures are claimed to both heat treat and clean in one operation. There is a greater tendency to use controlled atmospheres to avoid costly scale.

Some important wire specialties were developed late in the war. Aircraft manufacturers had been having trouble with steel wires used as control cords because coefficient of expansion differed from that of the aluminum alloy fuselage. Some of the time these cords were too tight and at other times too limp. At length an alloy in the stainless steel family with an expansion coefficient almost as high as aluminum has been used satisfactorily. It far excels the high strength carbon steel wire formerly used.

In the last year or two some ultra fine wire has been developed, 0.010 to 0.001 in.; also even finer. They are used for electrical purposes, electronic tube grids and filaments, jewelry, X-ray work, military gold braid, etc. Some fine wire work is done to tolerances of 0.0002 in. or less. Platinum fuse wire is taken down to 0.000017 in., or 1/1000th the diameter of a fine hair. Before the war much of this extremely fine wire was imported. One company turned out 0.013-in. reinforcing wire, 280,000 p.s.i., for Signal Corps field wire, at the rate of 1600 tons, or 1,300,000 miles, per month. Many sizes from 0.008 to 0.020 in. were produced in comparable lengths.

Extruding

Probably the most spectacular development of 1944 and early 1945 was the extrusion of high melting point metals such as nickel, Monel, Inconel, gilding metal and copper. Hitherto most of these metals and alloys were produced in this country by piercing, then cold drawing, but some alloys such as "K" Monel, cannot be pierced. It was revolutionary, therefore, when International Nickel set up a 4000-ton extrusion press at Huntington, W. Va. Tubes of nearly 9 in. O. D. and 8 in. I. D. were the largest produced to date. It is not outstanding because of size alone, since a 5500-ton press already exists for extrusion of aluminum and magnesium alloys.

An important aluminum extrusion development of 1945 was the "stepped extrusion." This provides an extruded shape that increases in cross section in steps from one end to the other. Announced in 1944, the most progress was in 1945. In early stages it was desirable to maintain one surface common to both the large and small sections. But now no common surface is necessary. However it is not yet possible to produce stepped extrusion large at both ends and small in the middle, or vice versa. Technically, it is feasible to make extrusions with as many steps as desired, but this would increase the time needed and complicate the straightening problem.

The first commercial extrusion of zinc alloys as well as of special high grade (99.99% pure zinc), prime western and intermediate types came in 1945. Efforts to extrude these metals previously had not resulted in commercial success.

Extrusion is done in conventional vertical presses such as used on some other "white" metals, especially magnesium.

(The following, in addition to those quoted in the article, gave valuable help in the preparation: C. R. Maxon, New Jersey Zinc Co.; H. C. Boynton, John A. Roebling's Sons Co.; G. G. Beard, United Engineering and Foundry Co.; Robert L. Zahour, North American Philips Co., Inc.)

Powder Metallurgy

Reviewed by T. C. Du Mond

PRODUCTION OF POWDER METAL parts is divided into four different divisions—according to the products being formed by this method. The types —of course—are mechanical parts, carbide and similar tools, oilless bearings and friction parts. Each type of production has its own peculiar problems and each production group has seen its own changes.

Since there are now only about two dozen companies engaged in the production of powder metal parts, knowledge is concentrated in the minds of a comparative handful of men. In the past each of these men—or at least the men of any one company —has tended to keep all his knowledge to himself. During the last year, there has been a greater interchange of knowledge which tends to remove the entire field from the fog of secrecy in which it has long been hidden.

Powder metal parts have gained in stature since recent news releases from the Navy department described the accuracy of radio proximity fuses, the accurate action of which depended, to a large degree, upon the passing of mercury through a porous metal cup. This cup, of porous nickel, demonstrates the accuracy of characteristics which can be produced in parts of powdered metals. Control for such production extends all through the production processes, back to the producers of metal powders. Metal powders for such uses must be spherical in shape and particle size must be exact, for odd shapes and sizes would offset all other efforts to gain exact porosity. Similar types of porous metal filters are being made from other types of metals with like results.

Porous filters require sintering in molds, generally, because pressures used in compacting the metals are too low to cause the powder particles to hold together.

Much publicity has been given during the last year to huge parts produced through powder metallurgy, especially bearings ranging in size up to 228 lb., with regular production of bearings in the neighborhood of 75 to 100 lb. However, these sizes are not practical in producing mechanical parts from metal powders, for there is not the same advantage as is obtainable in producing oilless bearings.

Another metal has been added to this list of those that have been formed into oilless bearings and that is aluminum.

Practical Sizes Defined

There is a general feeling that mechanical parts of metal powders can best and most economically be produced in sizes up to about 6 sq. in. surface area and weighing 2 lb. or less. As press sizes, capacities, and control increase the practical size of parts produced may increase accordingly.

As the physical properties of parts made through die casting increase, there is a reciprocal move throughout the powder metallurgy field to increase like properties in the parts produced by this method.

As an example of the new metals to produce higher physicals is one known as Pomet 141, described as being corrosion resistant. Physicals are recorded as, yield strength, 37,000 p.s.i., tensile strength, 58,000 p.s.i., and hardness 70-90 Rockwell B. Some producers have reported making parts from steel heat-treatable to Rockwell 62 C, although this is by no means common. Highest hardness ordinarily obtainable is around 35-40 Rockwell C.

Along with the desire on the part of many designers, those using powder metal parts are anxious to use this stainless steel in this type of production. Experimentation in the use of stainless steel powders has reached the state where the use of these materials are now considered entirely practical for commercial application.

The advent of new materials and higher physical properties make necessary better control over time, temperature and atmospheres used in sintering the compacted parts.

As with parts produced by other methods, there is often need to add an electro-plated coating to powder metal parts. Chromium plating has been successfully applied in the past, but during the last year methods of plating with cadmium and zinc were

successfully introduced. In plating powder metal parts extreme care must be exercised to prevent the inclusion of moisture in the parts under the plating. Such moisture would eventually result in intergranular corrosion that might cause failure.

It is difficult to choose any particular development during 1945 in the field of powder metallurgy as outstanding. Many of the techniques—and the equipment—used are known only to the particular producer that developed them. Too, many products and the methods used to produce them are still cloaked in secrecy because of their military nature. However, one man prominent in the field declares that the most important development in the field is its recognition and praise by military authorities. It is his feeling that powder metallurgy has now arrived and that it will continue to grow steadily, even though unspectacularly.

At the present time, the powder metallurgy field is operating at less than its most active pace due to reconversion. Much of the growth in this production method in recent years has been due to war requirements. Now that this demand is over, peacetime requirements have not yet taken up the slack. Being essentially a subcontracting business, at least that segment devoted to producing mechanical parts, the business cannot create its own demand except by showing parts' users where and when powder metal parts best can be used.

Greater Accuracies Held

One of the biggest advantages of producing parts by powder metallurgy is the fact that such parts require little or no machining. Thus, powder metal parts are now being made to even greater accuracies, in keeping with the more important applications. Tolerances are being held to as little as 0.0005 in., when required. Accuracies of this closeness are generally obtained through the use of a final sizing operation after sintering.

Mechanical presses have long held the lead in producing powder metal parts, especially where extremely dense parts are required. During the last year there have been more hydraulic presses, since some such presses have been especially designed for production of powder metal parts. These presses are automatic in charging the mold, briquetting the powder and ejecting the finished part. Too, hydraulic presses permit closer control over pressures and thus over the resulting densities. One hydraulic press operates with equal ram pressure from top and bottom, with the idea of giving a more even density throughout the piece.

The manufacture of clutch plates, friction disks and similar parts of powder metals, or of powder metals backed with steel plates, received great impetus during the war. At the present time there is some question as to where this branch of the field may go. It is likely that such parts will continue to be used in heavy-duty trucks, farm equipment and machine tools. There has been little new in methods of producing such parts, at least little that has been made public.

Since solid carbide tools and cutting tools of similar nature are finding much more extensive use and are being used more frequently as solid tools rather than tips on tool steel or cast iron. Thus, more and more companies are eyeing this field. Dies for this type of production are not as critical as for most powder metallurgy production, the emphasis being on high pressures for proper density and high sintering temperatures for proper joining of the elements involved.

Hot Pressing Increases Physicals

Experimental work has shown that the physical properties of powder metal parts can be increased by hot pressing, rather than cold pressing, as is now done commercially. The application of heat during the pressing operation results in an increase in plastic deformation of the metal powders and practically assures the part being free of all voids.

Commercial application of this method is limited at present by a lack of die steels capable of withstanding high pressures at high temperatures; need for a high temperature lubricant capable of preventing excessive die wear; means of using controlled atmospheres in the compacting zone and of ejecting finished parts into a neutral atmosphere for cooling.

Experimentally the hot pressing is being done by the use of induction current passed through the powder mass as well as by enclosing the die assembly in a furnace.

Results obtained in one test were reported as follows: A precompacted part of electrolytic iron powder, having an apparent density of 2.4 grams per c.c. was placed on a heated die and allowed to soak for 10 min. after which a pressure of 10 tons was applied. Density increased markedly with increased time and temperature up to 1290 F, and hardness increased up to the same temperature. Likewise a tensile strength of 55,000 p.s.i. was recorded at 1290 F.

Because of the increasing applications of powder metallurgy, material costs are coming down thus making possible the even greater application of this production method. Also bound to help in the further use of powder metal parts is the development of methods for obtaining even finer tolerances than are now commercially possible. This may involve the use of progressive or varying shaped male dies to provide a variety of pressures on complicated parts. The use of step dies may also result in higher physical properties, as these properties are closely allied with density of the finished part.

Machining demands now are for one operation finishes, rather than the former idea of a roughing and then a finish machining operation.

Machining

Reviewed by T. C. Du Mond

THREE WORDS QUICKLY point out progress in the field of machining—and the equipment which performs machining operations. Those words are speed, accuracy and control.

Quality machine tools have always been considered accurate, but the accuracy of work now being done would put many of the old machines and machinists to shame, for finishes that once took hours to attain are now achieved in a matter of minutes or even seconds. These results are due partially to the machines, in part to changes in cutting tools, but even more to the fact that those people responsible for determining methods of machining have learned much about what really happens when cutting tools or grinding wheels remove metal. By knowing what happens and why, men in such positions can determine most suitable feeds, speeds, cutting materials and coolants to do the best possible job.

To those persons waiting with bated breaths for a flood of radically different machine tools to be announced immediately after V-J Day, there has been little satisfaction. There have been a few new machines announced, but these are nothing as compared to those which will come during the next few years.

That is one reason why the Machine Tool Show—suspended in 1940—will not be resumed until 1947.

The majority of machine tool manufacturers have ideas for new equipment, but most of these ideas are just reaching the early design stages—a long way from the shipping room floor. This condition is not due to lack of foresight on the part of manufacturers, but prevails because all machine tool builders have had to use all available engineering talent to solve the more pressing problems of war production tooling. Now the design engineers are being turned to the task of building machine tools that will incorporate features to do best all those things which it is now known machine tools can do.

It is difficult to predict just what improvements individual designers will incorporate in their machines, but among the anticipated advancements will be more automatic speed selectors, built-in lighting, more readable dials and handwheels, multiple controls and the use of electronic devices where applicable. One recently announced milling machine has a flywheel mounted on the spindle to insure a uniform flow of power.

In equipment announced thus far most emphasis is placed on the automatic control of machines. One example is the Man-Au-Trol system which permits the operator to preset all operations on extremely complicated machining jobs and then perform the machining automatically. Such controls do not prevent the machine from being operated manually when such operation is desired. The Man-Au-Trol was designed originally for use on vertical turret lathes but can be applied to other machine tools as well.

The Man-Au-Trol is capable of handling any number of functions up to 39 automatically without human or cumulative error and at much faster rates than could be achieved manually. On one job the Man-Au-Trol set a rate of 10.5 min. floor-to-floor time on a complicated job which formerly required over one hour per piece.

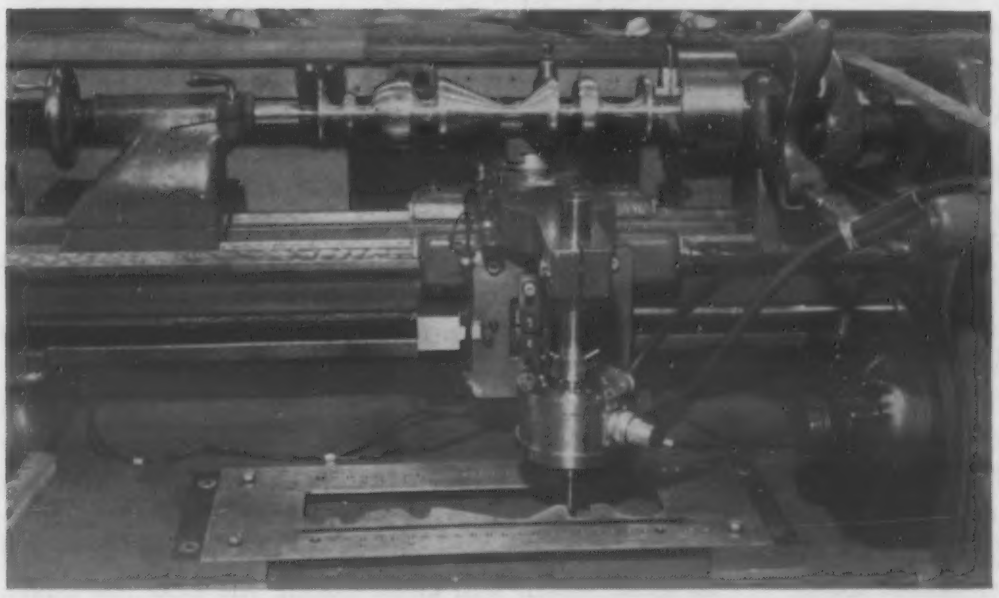
Setting the controls is quite a simple task. The work piece is placed in the chuck and located then the tools are put through each respective cut manually. At the completion of each cut a setting is made on the Man-Au-Trol. When all operations have been completed and all function stops set, the lathe is thrown into automatic operation.

Another development with a somewhat similar purpose—namely taking much of the burden from the operator and incorporating the functions in the machine—is the Electro-Cycle turret lathe, designed especially for working non-ferrous metals. Even in completely automatic machines special designs are being provided to accommodate certain classes of materials.

Control All Functions

These developments spotlight what will probably be an overall trend in machine tools now being developed. Controls of all kinds are being incorporated in machines to govern carefully all of the functions of individual machines and to make certain that the equipment is not misapplied. For instance, in a recently announced milling machine the spindle motor must reach the selected speed before the feed motor will start.

While some radically new machines were announced recently, the greatest development has been in cutting tools and in work holding devices. Carbides have emerged from the aura of mystery and have been reduced in price sufficiently to make their use possible in any metalworking plant. Improved techniques in treating high speed steel tools have added to their life and productive abilities. Pneumatic and hydraulic work holding fixtures reduce time re-



Automatic contouring control systems are being applied to all types of machine tools. The shape on this lathe is copied from the templet in the foreground. (Courtesy: General Electric Co.)

quired to load and unload the machines. All of these changes work toward the same end—increasing productivity by reducing down time of machines to a minimum.

Carbide milling is by no means new, but its importance—at least as far as the machining of steel is concerned—is probably greater than any step forward in recent years. It has such potentialities both in speed and quality of work that few if any machines in existence are capable of utilizing carbides to their full extent. Machines, except a few specifically designed for carbide milling of steel, do not have the speed, power and rigidity to take full advantage of the cutting ability of carbides.

At present there is a considerable conflict of opinion as to the best means of using carbide tools. In multi-tooth cutters the question is: "Shall we use brazed tips on cast iron or steel bodies, or shall we use solid pieces of carbide as would be done with high speed steels?" Opinion seems to favor the latter method, for several reasons, including the elimination of a brazing operation, reduced cost of carbides, and the fact that inserted, mechanically held cutting blades can be changed and sharpened much easier than brazed on tips. In the case of single point tools, brazed tips are most commonly used, but lately rather successful experiments have been conducted using clamped-on carbide tips. Results of clamped tips are faster speeds, deeper cuts and better finish.

The use of hyper-milling (extremely high speeds and heavy cuts with carbide tools) first took hold in the aircraft field in milling large sections of aluminum and magnesium. The success in cutting these metals at almost unbelievable speed and feed rates led to investigations into using the same techniques on harder metals, particularly steel. In a recent group of demonstrations a group of machine tool builders and other interested persons were shown dural and magnesium being milled with spindle speeds of 6000 r.p.m. Finish attained on these materials at these speeds approached 2 or 3 microinches. In many cases metals are being machined, through the use of carbides, at speeds equal to or surpassing those used in woodworking.

Even though carbide milling of steel, aluminum and magnesium was greatly extended during the war there were still many jobs where it could have helped speed production. An example is currently being demonstrated on armor steel for tank turrets. Throughout the war this particular piece was machined at a feed rate of ⅜ in. per min. Now a superior finish is attained on the same material at a feed rate of 17 in. per min. Early in the use of carbides for milling steel much of the stock removal was by means of fly cutters. Now inserted tooth cutters are used with the results that there is less shock on the machine, greater cutting speeds are possible and smoother finishes are attained.

Because of the spectacular possibilities of carbide milling and turning, there has been considerable research into the proper angles of the cutting tools involved. Indications at this point are that a combination of negative and positive rake and relief angles are most satisfactory for high speeds and maximum tool life. However, as research progresses the exact angles and combination of angles for various materials will be definitely and certainly established.

Carbides Offer Design Challenge

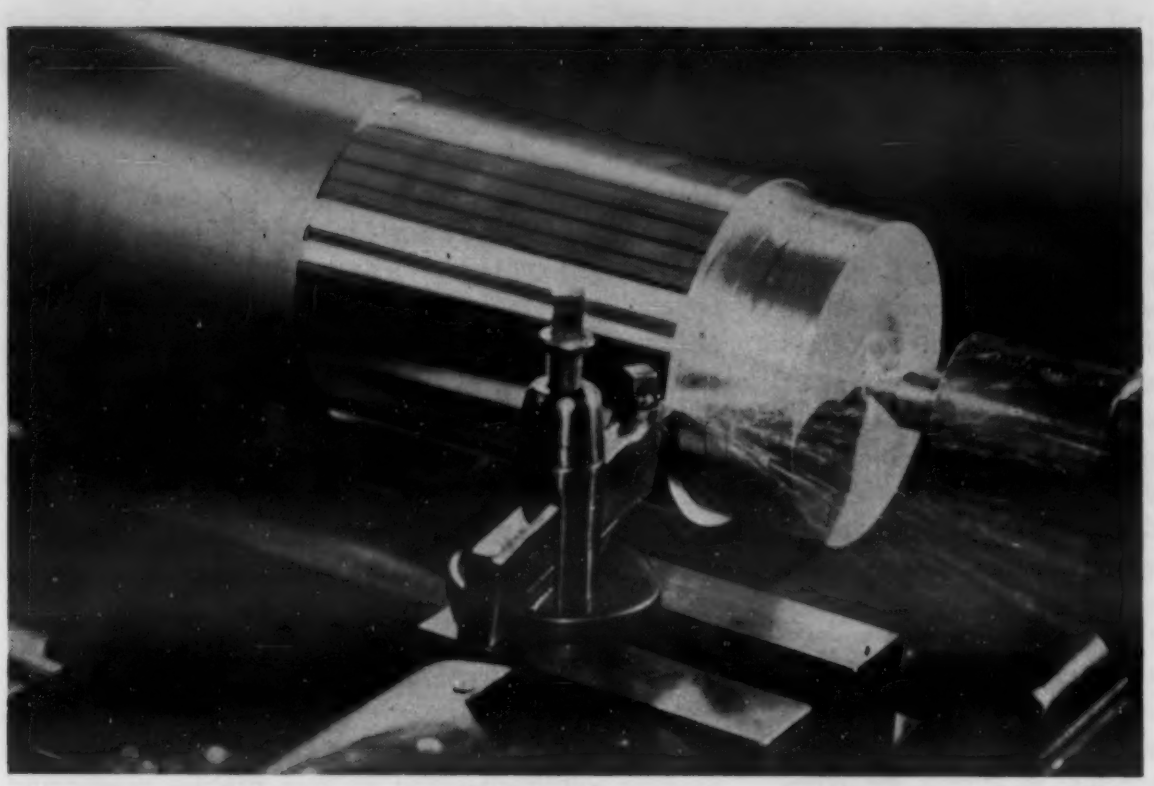
Now in designing new machine tools the question has arisen as to just how much power and rigidity to build into the machines. Designers want to make the tools suitable for carbide cutting but still not provide excessive power or make the machines too heavy, bulky and costly. Probably the answer will be found only after considerable experience with newly designed machines operating under actual manufacturing conditions. There is a possibility that a compromise will be reached to give highest power and speed within certain cost limitations.

Due to a natural lethargy of manufacturing executives to adopt new methods, it is estimated that carbides are being used on only 10% of the jobs where they could be applied with advantage. The percentage of users is bound to rise rapidly as economic pressure forces manufacturers to take every possible step to speed output and decrease production costs.

The use of high speeds and deep cuts in machining has imposed another problem in connection with coolants. The great heat generated in these cutting processes often raises temperature of cutting compounds to the point where they lose their effectiveness. While experimentation continues in an effort to find exactly the right coolant for the material and the process involved many shops have solved their immediate problem by refrigerating the coolant by mechanical means. It is known that keeping temperatures of coolants constant has a decided effect on improving tool life and getting better finishes.

In designing new machine tools there is a determined effort to make as many operations automatic as is possible. There are many reasons for the direction of this effort. Reasons include: Making the machine as foolproof as possible; speeding production by eliminating manual changing of speeds, feeds and other settings; and generally reducing costs.

Along with the new machines to be introduced, there will be a general reduction in the age of machine tools in service throughout this country's manufacturing plants. This situation results from the terrific production of machine tools during the war years. Although many of the tools produced were special purpose machines there were also very large quantities of standard machines. According to the National Machine Tool Builders Association, the bank of machine tools is having little or no effect



Fine surface finish and deep cuts are combined in machining the light metals, such as this magnesium alloy billet.

on the demand for new tools. The fact is that the backlog of orders for many tools is mounting rather than experiencing the drop which had been anticipated. The extra standard machines turned out for war production will find their places in relieving machines that are greatly over-aged and as initial equipment in some newly-started plants.

Tool Room Accuracies in the Shop

Now that some of the startling machining feats performed during the war are being talked about, one truth is evident. Tool room accuracies are possible on the production line and at production line speeds. An inevitable result will be that even tool room work will be performed at much faster rates, with a resultant cost reduction and no lowering of accuracy. The same speed-up will result in job machining shops and in plants where machining is a comparatively minor function.

One bit of war production shows what can be done by a combination of excellent machine tools and intelligent engineering. In making pumps for B-29s, high accuracy was demanded for efficient operation. Roundness of pistons and cylinders through which gasoline passed had to be held to ten-millionths of an inch; equal accuracy was required in straightness of parts; size was critical. Finish had to be held to approximately five microinches, for a coarser finish gave initial wear that was excessive and shortened pump life considerably.

The job was performed on a special grinding machine with a work spindle which would generate the required roundness. The slide which controlled the amount of feed for the grinding is so sensitive that it is possible to backoff the wheel and then return it to take out another ten-millionths of an inch of material.

Wheels are mounted on high frequency spindles. Rotors are directly mounted on the spindle shaft, eliminating all the disadvantages of belt driven spindles and permitting considerably higher speeds. Through such a design spindles are being run at 100,000 r.p.m. commercially and considerably higher experimentally.

Machines and techniques for working to such close limits are an important contribution to the future. They make feasible mechanisms that have heretofore been considered impractical. The practical result can mean better performance and longer life on such products as ball bearings and diesel fuel nozzles.

The accurate generation of threads—regardless of whether the method be machining, grinding or rolling—has always been a problem, especially when the problems of time and cost are considered. Several developments in this field are of more than passing interest.

Thread Rolling Progresses

Perhaps greatest progress has been made in thread rolling. Equipment is now available which will produce rolled threads to a degree of accuracy and with a finish that would not have been considered possible two years ago. Threads are being rolled to greater tolerances than can be ground on a commercial basis. There are some problems, chiefly a matter of speed, in rolling threads in heat treated materials. However, developments now in process give promise of overcoming this obstacle.

Grinding screw threads by crushed form wheels has received considerable attention during the past year when this metalworking method was put to considerable practical use. It is believed that considerable development work will be done in this field in the near future because of the method's value in generating threads in materials of such hardness that rolling or cutting is unsatisfactory.

In the other type of thread generating—namely, thread cutting—equipment and die heads are now available which can produce threads to Class 4 tolerances on a production basis. Accepted as a common thing today this quality thread cutting was considered impractical just a few years ago.

Thread milling has now been developed to a point where the standardization of cutters is justified. Such cutters are now produced in mass quantities in heat treated blank form and stocked. A short time ago this method was considered not sufficiently accurate for widespread use in view of close tolerances required.

One of the most critical items of production during the war was gears. All methods of gear production came in for attention, with gear shaving making the most progress. Several types of equipment were used, the latest of these being a machine which cuts all teeth of a gear simultaneously, thereby reducing production time for cutting a gear from minutes to seconds. Advantages given for gear shaving include: Better finish, greater accuracy, and the elimination of "burning."

Broaching has emerged from the war as a method which can be used on comparatively short-run work, stepping out of the strictly high production class. During war production, this method was used for such fussy work as gun barrel rifling. In the high production field, broaching is expected to be used extensively in machining cylinder blocks and many other automotive parts where quantities are large and speed important. Both broaching machines and work holding fixtures have been vastly improved.

With steady progress in all fields of metal shaping, it is inevitable that as production techniques advance there will be a steady decline in the proportion of machining done. Stampings reduce machining needs, more accurate forgings leave less metal to be removed and the widespread use of die casting, precision casting and similar methods reduce still more total machining requirements. There will be less instances where, for instance, a 100-lb. forging is reduced through machining to a piece weighing about 20-lb.

Almost anything that can be cut from a pattern or templet with a motor-driven tool can be produced accurately and completely automatically with a machine equipped with a new automatic control system which seems to have a sense of touch. When a change in contour is encountered by the tracer, two feed motors change speed simultaneously to reproduce the same contour on work in the machine. Tool motion is continuous and at a constant rate, insuring a good finish. Many complicated parts for turbo-superchargers and jet engines were machined on equipment having such control.

All of the above mentioned factors place a heavier responsibility on machine tools and machining methods. Machines must be faster, more accurate and easier to operate. Machine tools meeting these requirements will be introduced regularly from now on.

While the methods are not new, there has been a great increase in the use of tracer-controlled machines on which the cutter is guided by a simple master or hand made original piece. At one stage of their development such machines were considered primarily as tool room equipment—particularly for die sinking and mold making. Complex shapes required for many war products would have been extremely difficult to produce in any reasonable time were not tracer-controlled machines available.

One Machining Operation

Finally, there has been a great change in the entire process of machining. Until a very short time ago, machining, at least milling and turning, was divided into two parts—roughing and finishing. In many cases different tools, different speeds, feeds and depths of cuts were used. In some instances different machines were even required. This obviously wasted—and in many cases still wastes—much productive time. Now it is possible to obtain finishes down to a few microinches in one pass of the cutting tool across the work at terrifically high speeds and while taking exceptionally heavy cuts.

One lesson learned during the war is being applied in many plants during their reconversion to normal production. Rather than adhering to the old system of having separate departments divided according to equipment, production departments are being assigned all of the machines that are required to handle the production of that department. In addition, machines are placed in the order of their use. This means work flows along smoothly with a minimum of handling. Such a simple step as this has had a great effect in reducing overall costs of production, for, as it has been learned, material handling is one of the greatest non-productive costs in any plant.

The editors wish to express their thanks to the following companies for assistance given in supplying information on which this article was based: Bryant Chucking Grinder Co., The Bullard Co., Carboloy Company, Inc., Cincinnati Milling and Grinding Machines, Inc., Colonial Broach Co., Denham & Co., Genesee Tool Co., Giddings & Lewis Machine Tool Co., George Gorton Machine Co., Kearney & Trecker Corp., Kennametal Inc., Landis Machine Co., Michigan Tool Co., Sundstrand Machine Tool Co., Tungsten Carbide Tool Co., and The Warner & Swasey Co.

Heat Treating and Heating

Reviewed by T. C. Du Mond

PROGRESS IN THE FIELDS of heating and heat treating has been more a matter of attitudes than actual changes in physical processes. Naturally, there have been a few new types of equipment introduced during 1945 and there have been further refinements in previously introduced methods, but none of these have been spectacular.

As to the changes in attitudes, heat treating equipment has gained a new respect, the value of control is more clearly recognized, and the desire to mechanize heat treating equipment is universal.

More than one person has remarked—and with considerable justification—that heat treating equipment is now in the same category as machine tools and other production equipment. A more pronounced definition of the place of heating and heat treating furnaces, ovens, machines and flames is probably the most outstanding development in this field during the last year.

Heat treating's new estate is not merely due to the fact that its tools are taking their places in their proper and logical positions in production lines along with lathes, grinders, drawing presses and other machines. Probably it has earned its new recognition most readily because of the complete control that is now possible over all of its functions.

Control is now rather complete over actual heating operation including time, temperature and like factors, but even more important is control over the final results. We can now control—with very little variation—the final condition of hardness, amount of carbon added to or removal from the surface of steel, color of the part being treated, depth of hardness, area to be affected, and any other physical characteristic of the metal, including whether its structure shall be lamellar or spheroidal. In the article "Instrumentation and Process Control" in this issue is described a new control which anticipates rise and fall of furnace temperatures.

There were no new heating methods or techniques introduced during 1945, but we did see greater recognition and application of two of the most recently adopted commercial methods—namely salt bath heating and the use of radiant ceramic burners. Too, we have seen methods developed for the successful accelerated age hardening of such tricky alloys as 75S aluminum.

Hand in hand with the trend of putting heating and heat treating equipment in the production line is the desire on the part of production men to mechanize the equipment as much as possible. Pusher furnaces were steps in this direction, but more recent installations are such that the parts do not have to be placed in trays or on trucks, but can be handled on overhead conveyors—being carried through heating and treating cycles on the same conveying equipment that takes them through the other production processes. The above mentioned desire has been responsible for increased acceptance of salt bath heating, where there is no need to be concerned with protective atmospheres, muffles and similar factors.

Out of the field of heating, but of vast importance to the man concerned with heat treating, is the setting up of a group of steels known as the H-steels (See the article "Irons and Steels" in this issue). These steels have been designated according to rather narrow hardenability bands. In effect the H-steels assure the user of materials with a minimum carbon content, and permit him to specify his steel according to the desired qualities rather than by chemical composition. More important, after he has once established his method of treating the steel, he can be assured of almost exactly the same results day after day and year after year as long as his control remains the same. Now that measurement instruments and control devices are available to measure and regulate time, temperature, atmospheres, dew point and any other critical factors there is really no excuse for poor heat treating results.

Still in the laboratory stage, but a distinct possibility of the not too distant future is a controlled atmosphere annealing process in which the material being treated will acquire a corrosion resistant finish. The finish will result from a reaction between the materials being heated and chromium, zinc, nickel and other metallic vapors suspended in the atmosphere.

It is rather interesting to note in passing that despite the new methods of heating developed during the last decade all of the old standby methods continue to hold their own. The answer must be found in the fact that there is a considerably increased use of heating and heat treating throughout industry. The introduction of new heating and heat treating methods has merely added more ways of bringing out the best in metals and has given production engineers and designers additional tools to work with.

At the present time, salt bath heating and quench-

Great reliance is placed on hardenability tests to determine proper treatment for metals. Some steel specifications are now made on hardenability rather than on chemical composition.

ing is receiving a lion's share of attention from the metalworking industries. As a matter of fact, it has become of such interest in such a comparatively short period of time that it becomes the answer in the minds of most people when they are asked about the most important heat treatment development during 1945.

This does not mean that salt bath heating is a development of 1945—or even 1944 or 1943—but its progress has been most noticeable during the last year.

When first used, pots for salt bath heating were generally of metallic alloys. The past year has seen most of the metals for this purpose replaced by refractory materials that have added from 2 to 4 years to the life of the pots.

With the use of refractory pots, salt bath furnaces now can be built to most any size and shape. Virtually unlimited sizes and shapes make possible to mechanization of the process for handling parts large or small.

Some installations use three or more salt baths to handle heating, quenching and tempering operations continuously without handling other than loading and unloading. Large tonnages can be handled automatically without sacrificing quality and at the same time matching mass production speeds of other processes. In one ordnance plant, it was recently disclosed, 10,000 lb. of critical parts were heat treated every hour by this method.

Salt baths are being used for hardening, carburizing, selective heating and interrupted quenching. Some treaters use salt baths for all three phases of heat treating—initial heating, quenching and drawing. In other cases, however, heating to hardening temperatures is done in gas or electric furnaces and then the parts are quenched in salt baths.

One of the newer brazing methods is through the use of molten salt baths. This method was once limited to brazing copper with silver solder, but is now used for joining many materials with other brazing alloys. Where parts must be both joined and heat treated, the two operations have been combined quite successfully.

Heating

Regardless of the method of heating and the purpose for which heating is done, efforts are being made to bring the heating operation as close to the next subsequent operation as possible. This makes possible greater speed; better work, as temperatures are at their proper point for the operation to be performed; and, in many cases, several reheats are eliminated because proper spacing of equipment permits all operations to be performed before the metal cools out of the working range.

Better heating has been widely applied in the field of forging. Atmosphere furnaces are used in many cases to reduce the development of scale on forging slugs thereby reducing metal loss and damage to dies which result from hard scale. Much of the heating

This conveyorized flame hardening machine uses six torches to increase production. (Courtesy: Air Reduction Sales Co.)

for forging is now done by induction heating by a continuous process, whereby heated slugs are constantly fed to the forging press, hammer or machine. This latter development speeds the entire forging operation, as properly heated blanks are always ready and waiting for the operator.

The past year has seen a greatly increased use of immersion heating. Much immersion heating is done by placing heating tubes directly into the solution being heated. However, some people have experimented with a "double boiler" type of heating pot. Under this arrangement, the material being heated is in one pot, which is surrounded by another pot in which the heating tubes are immersed in a neutral liquid. Satisfaction has been reported from the method for two reasons—more even heating results and protection of the tubes from corrosive action of solutions being heated.

Higher temperatures than normally attained with metallic-resistance furnaces were reached in rotary hearth furnaces in which the heating units are rods of pure molybdenum, formed into loops and supported by refractory insulators built into the inner loops and outer walls of the heating chamber. Operating at temperatures up to 2500 F, the furnaces were used to heat stainless steel parts for forging, heat treating alnico magnets and heating other special alloys. Protective atmospheres protect both the work and the molybdenum units.

Some heating equipment is tied into production lines as an integral portion of large special set-ups for particular jobs. One instance of this is a production line which includes three drawing presses and three annealing furnaces. Blanks of the part to be formed are placed on the feed mechanism of the first press and from then on the parts go through the entire process without being handled manually, emerging at the end of this special unit in final shape and having been given the final anneal.

In induction heating, there have been made available standard coils which can be used interchangeably on the heating units for many shapes of parts.

Hardening

Hardening is a much more precise process now

Much of the impetus for automatic hardening came from induction heating machines. (Courtesy: Ohio Crankshaft Co.)

than it was even before the war. The past year has seen new theories which were given practical tests during the war years applied to consumer products. As one leader in the field asserts, the knowledge gained and techniques developed during the last few years make the iron-carbon diagrams practically obsolete.

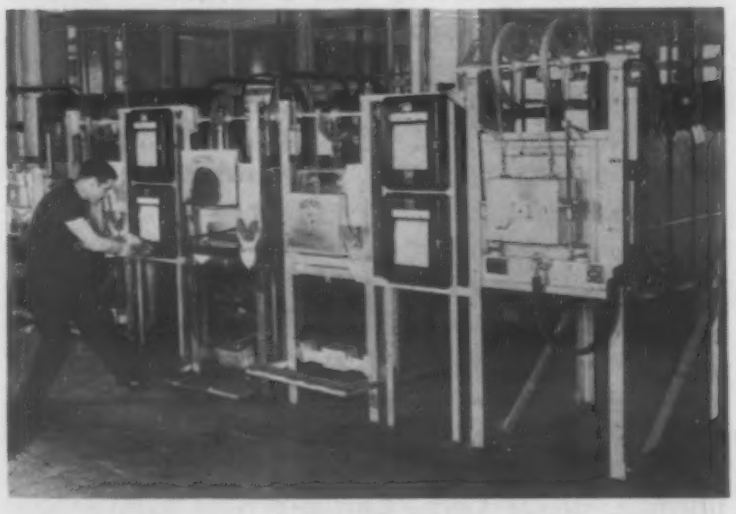
One lesson that has recently been learned will undoubtedly influence most peacetime production, and that is that heat treating can produce most desirable qualities in steels. Thus, many of the advantages of low-alloy steels can be had during machining and other processing and yet, through proper heat treatment, the final product can have the external hardness and internal toughness so often sought.

Properly recognized and exploited, the proper use of heat treatment can mean that a plant will require less inventory of steels and keep many less grades on hand. This will reduce costs generally and permit plants a much more thorough knowledge of the steels they do use.

Probably the one outstanding development in heat treating is the procedure for age hardening 75S aluminum alloy. Ordinarily this alloy does not become fully age-hardened until after it has stood at room temperature for about a year, with most of the hardening taking place after about 2 hr. at room temperature immediately after the quench. Early methods of age hardening 75S consisted of holding the sheet at 250 F for 24 hr. or 275 F for 12 hr.

Now, however, it has been determined that better working characteristics are obtained through an interrupted technique, consisting of heating for 4 hr. at 210 F, cooling to room temperature and then aging for 8 hr. at 315 F. A similar application of artificial aging to 24S alloy had previously been developed and has resulted in the 24S-80 series of alloys with mechanical properties approaching those of 75ST.

Results of tests conducted on 75S for various characteristics show greater dimpling capacity when aged by the interrupted method.



Precise control is applied to small batch-type equipment as well as large automatic production units.

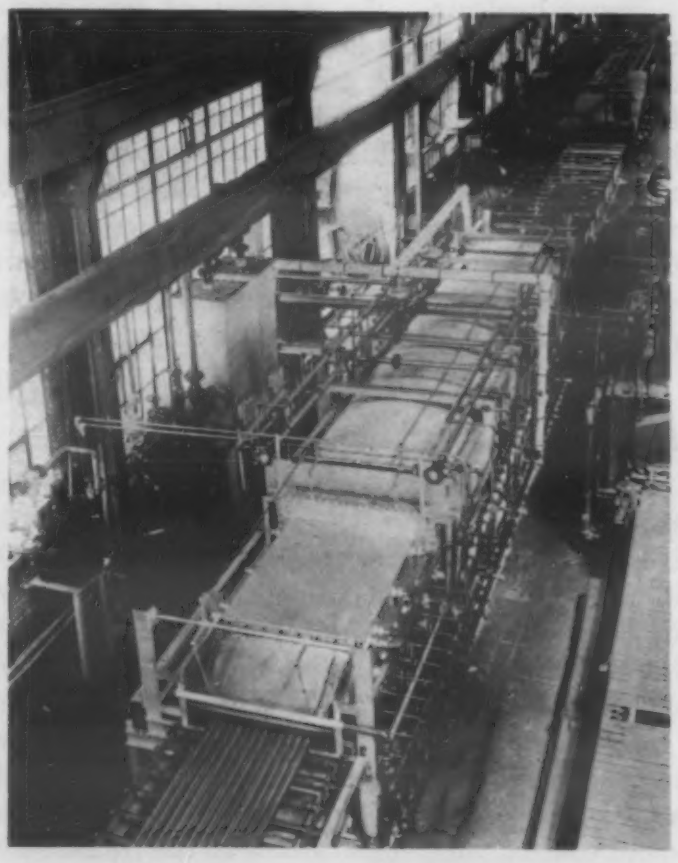
Electron-microscope research demonstrated that hardening of beryllium copper is due not to the formation of the precipitate in its "submicroscopic" state but to an order-disorder transformation occurring with the lattice of the metal.

Quenching

Close control over quenching has now reached the state where practically all quenching distortion can be eliminated. Too, many of the techniques now in use preclude subsequent tempering operations, thereby saving considerable time and fuel costs in bringing out desired qualities.

Salt bath quenching has become widely accepted where distortion is a problem, because unbiased studies show that this method of quenching—where the steel is held at a temperature just above the point where the transformation of austenite into martensite begins and then cooled in air—results in external temperature and center temperature of the piece being the same when the transformation begins. It is the variance of internal and external temperatures that causes distortion and cracking.

Thin and medium sections can be treated by interrupted quenching by controlled gas atmospheres. This method consists of rapid cooling in a prepared gaseous atmosphere which is circulated in large volume. Such a method combines the distortion-free quenching of air with the speed of other quenching media.



Steam is the protective atmosphere in this direct-fired roller hearth furnace for bright annealing copper tubing.

Recently there has been divulged an operation in which carburizing and nitriding are combined in the same furnace to produce small parts with clean, extremely hard surfaces with soft centers. In this particular shop a pusher-type muffle furnace is used, with a water cooled chamber at the discharge end. It requires 8 hr. for a loaded tray to make the cycle through the furnace—5 hr. for heating and 3 hr. for cooling. Close control of the 1425 F temperature produces a case of 0.004—0.006 in. although case can be increased to 0.012 in. by raising the temperature.

One of the difficulties of salt bath heating has been decarburization of work and electrodes after certain times, depending upon the salt and the rectifier used. Now a new salt is being introduced which is used in conjunction with a carbon rod in the bath. The carbon rod provides automatic rectification of the bath by supplying the carbon necessary to combine with oxygen in the bath to prevent decarburization.

Midway through the war, cold treatment of metals took a firm hold on production processes. Such treatment, in which the metal was held at temperatures ranging down to −120 F, was used for various purposes, including accelerated grain growth to stabilize steels such as are used in gages, preventing the age hardening of aluminum alloy rivets and adding to the hardness of tool steels by making more nearly complete the formation of martensite.

Indications are that cold treatment will be even more universally relied upon in future production, as demand for suitable equipment is now taxing the capacity of producers of refrigerating equipment.

Flame hardening, the simplest of heat treating methods, has emerged from the war as an even better, more reliable and more versatile method than it was in the past. Huge gears that could not have been heat treated with any degree of satisfaction or economy by any other method are being heat treated and quenched in automatic flame hardening machines. Complete control over flame temperature and time elements make flame hardening as safe and sure as other methods of heating currently used.

Annealing

As another step towards mechanical handling and the elimination of batch handling wherever possible, it is interesting to note the development during 1945 of methods of continuously annealing strip metals in a vertical furnace. Most operating experience has been with nickel-silver, beryllium copper, cupronickel, phosphor bronze and brass.

One outstanding method of continuous strip annealing uses a vertical, electrically heated, controlled atmosphere furnace, with automatic temperature and speed control. Strip goes directly to the furnace without previous cleaning or degreasing, leaves bright and glossy and—with the exception of beryllium copper—none of the metals mentioned require subsequent surface treatment. Beryllium copper is given a flash pickle.

In addition to producing a properly annealed strip, this method saves considerable time in elimination of batch handling, preliminary cleaning and subsequent finishing operations as well as reducing production time on finished parts which might require extensive buffing or polishing to remove etching or pitted spots due to pickling.

The method is extremely flexible as to width and gage of strip handled and as to speeds available. Speeds range from 3 ft. per min. to 15 ft. per min. and capacities range from 300 lb. per hr. to 1000 lb. per hr., depending upon the nature and gage of metal being annealed.

Materials other than those mentioned are being successfully annealed by the strip method, and it might find great application in the future in the steel industry.

An extremely satisfactory method of annealing 18:8 stainless steel has been found through use of a salt bath that prevents carburization or decarburization of the steel's surface. In this method a pure sodium carbonate that needs no rectification is used. Such a bath removes welding flux when such a flux remains on the surface. After being treated in the bath, the parts receive a cold water quench, are placed in dilute sulphuric acid to remove salt on the surface, rinsed again and then placed in a cold pickle. This leaves the parts with a clean, bright finish.

The present demand for every possible economy in production has resulted in an avid search on the part of engineers to apply all of the latest methods of heat treating to production of their normal products. Thus, they are eager to use methods which permit the part to come from the final heating operation in such a condition that no further processing is necessary except for the application of a finishing material, when one is needed. So many plants are merely awaiting the availability of new equipment to install in their production lines, so heat treated and quench parts will come from the furnaces free of distortion, with a properly hardened skin and without discoloration and scale.

The demand goes further than his own plant, however, and it has resulted in steel mills being asked to furnish cleaner steel which has been subjected to surface recovery treatment. This reduces the quantity of material used and in many cases eliminates the need for a grinding or machining operation to uncover a satisfactory surface and might also eliminate the need for carburizing in the user's plant.

The editors wish to express their thanks to the following for making available to them information on which this article was based: Ajax Electric Co., American Iron & Steel Institute, Battelle Memorial Institute, Breeze Corp., Curtiss-Wright Corp., General Electric Co., The A. F. Holden Co., E. F. Houghton & Co., Pratt & Whitney Aircraft.

The heliarc method of welding has been extremely successful in joining magnesium sections, where the prevention of oxidization is an important factor. (Courtesy: Northrup Aviation)

Welding, Joining, Fastening

Reviewed by T. C. Du Mond

WITH ONE OR TWO NOTABLE exceptions, progress in the fields of welding, joining and fastening have been steady and natural rather than fundamental and spectacular.

Nor, has progress been limited to the newer methods of joining metals or metallic structures. There have been notable steps forward in such unglamorous fields as the basic one of joining parts together by bolts and nuts. Indeed, no phase of the large field being scanned in this article has remained unchanged.

Many of the phenomena and simple mechanical facts of fabrication of parts—the word fabrication used in the sense of joining two or more parts together—have long been accepted without challenge. The last year has seen the start of considerable research to learn how and why, for instance, a nut works loose from a bolt, or why a welded structure suddenly fails. The realization of a need for further basic knowledge and the activation of many comprehensive research programs ranks, in the minds of many technical men, as the major development in the field of metal joining. Such research will continue, probably at an accelerated pace.

Welding—and its sister process, brazing—has come forth with at least one major advance, and the increased application of previously introduced advancements ranks near the fore in demands for attention.

During the war, many plants were introduced to welding as a production method. Some of these shops had never considered welding as a means of fabricating their own products, but now in their reconversion to peacetime production welding has taken a place for itself. This fact alone should result in further development in the various welding processes as existing equipment and processes are applied to problems other than these arising from the needs of war.

Multiple Arc Welding

A development that is likely to affect each of us, if not in the shop then in the home and all about us, is the introduction of multiple arc welding. This process combines the use of a.c. and d.c. currents and metallic and carbon arcs. Experts who have studied the process closely predict that multiple arc welding will permit better fabrication of most non-ferrous metals—especially aluminum and magnesium.

While the method is new and thus far little used, its value has already been proved in welding difficult alloys in thin gages. If the process has all of the advantages claimed for it—and indications are that it does—we are likely to see a vast change in aircraft construction. Despite all of the places where welding has been applied in plane fabrication, a glance at any

modern plane will reveal that thousands of rivets are being used. Multiple arc welding should dispense with the need for a large number of these rivets, resulting in stronger joints and less air drag on plane wing and fuselage sections.

Naturally, application of multi-arc welding is not limited to aircraft manufacture. In fact, it has been pointed out that a common household annoyance virtually will be eliminated. This happy state will be achieved by welding handles to aluminum pots and pans in such a way that they never can come loose. These are but extreme examples of the uses of multiple arc welding—hundreds of other applications will come into being.

In the process the metal electrode is supplied with d.c. current and two carbon electrodes use a.c. current. Five arcs result, three between the electrodes, one between the metal electrode and work, and one between a carbon electrode and the work. Such an arrangement results in easy control and concentration of heat. Through such control and heat concentration aluminum sheet 0.016-in. thick has been butt welded without shielding and without back-up strips.

Among the materials successfully welded by the multiple arc process are: Aluminum—2S, 3S, 52S, 61S, 24S, R-301, 14S, 75S, R-303; magnesium—3S, 57S; steel—4130, 8630, 1020; other metals—Everdur, brass, copper, 18:8 stainless, Alumel, Chromel. Several of these previously had been considered unweldable.

Tests indicate that fatigue strength of multiple arc welded joints in 0.040-in. 24S-T Alclad ranges from 10 to 125 times greater than riveted lap joints and nearly as much greater over spot welded lap joints.

Inert Gas Shielded Welding

While not strictly a development of the last year—or even the last few years—the increased use of inert gas shielded electrode welding demands that it be given attention. During the early stages of the war, this type of welding was relied upon more and more, especially in welding magnesium. The inert gases overcame many of the difficulties of welding this material—chiefly by excluding oxygen and hydrogen which affect quality of the weld.

As with most welding methods, this was first developed as a manual process. Now, however, there are several kinds of automatic equipment. When automatically applied, inert gas shielded electrode welding is faster than any other current welding procedure.

The most general applications of inert gas welding are, in addition to magnesium, welding aluminum and stainless steel. More limited applications have been made on Monel, Inconel, nickel and mild steel. A variation of the general method was used on a highly restricted basis in welding aluminum gasoline tanks. Here, argon was used to shield a high voltage a.c. arc.

A new development which can mean the welding of steels once classed as unweldable—notably steels with high sulphur contents—is the perfection of ferritic electrodes. Such electrodes are essentially mild or low alloy wires with stainless steel types of coating. Ferritic electrodes produce weld metal with a minimum of hydrogen content and have found wide use in welding steels of high hardenability.

One of the very apparent trends in the entire field of welding is the ever increasing use of automatic welding equipment. This trend is true regardless of the size of shop, the amount of welding being done and the method employed. The plant using automatic equipment need not be producing weldments on a mass production basis, in fact some plants are using automatic equipment in circumstances where only one or two large weldments are completed each day. Under the latter conditions there generally is greater uniformity of weld, faster welding and considerably lower cost. Automatic equipment is available that will move along the work to complete the weld, and, of course, there is also equipment that remains stationary while the work is fed to it.

Along with other steps to assure better welding, welding societies have established a numbering system to classify welding rods according to the tensile strength of the weld metal. Colored tips are also being used on electrodes to indicate their composition or the material on which they are to be used. Both of these steps permit accurate specification of rods for the conditions imposed by the welding problem.

Advances in welding are by no means limited to arc welding. Both resistance welding and gas welding have also seen considerable improvement.

Storage Battery Welding

Perhaps the biggest step forward in resistance welding is the perfection of storage battery welders. This type of equipment has been under development for several years, but it really came into its own during 1945. The apparatus consists of standard type wet cells connected directly to the electrodes of a pedestal or gun type welder. Batteries are charged through a rectifier operated from an a.c. source. Storage battery welders will deliver 20,000 amp. at the rate of two 15-cycle welds per min. This is sufficient current at a high enough welding speed for the heaviest type of carbon or stainless steel welding.

Because of the relatively low current requirements of storage battery welders, the use of this welding method can now be extended to small shops and out of the way repair stations. However, the large shops can use the equipment extensively because of its other inherent advantage—the ability to deliver a high current for relatively long welding times (10 to 20 cycles).

Most welding references bring to mind large sections or complicated machines. Here, however, wire so fine it can scarcely be seen is being welded.

Resistance welding equipment is becoming standard with its greatly increased use. Standardization has been made possible by development of standardized sub-assemblies, specially designed for such equipment.

On gas welding there has been considerably greater use of the pressure welding method. This type of welding has seen rather successful application in joining rails and pipes. Improvement in the method centers about better control of heat, time and pressure. Many plants engaged in fabrication of heavy, bulky products are investigating the use of pressure welding.

Gas welding in general will probably continue to increase in use as a standard manufacturing method. Its flexibility and relative low cost makes it the first choice for many products where there has been little previous experience, because an experienced gas welder can change his methods to suit the needs of special problems when and as they arise.

Brazing

Brazing, of all kinds—gas, electric furnace, gas furnace, induction, salt bath—has increased in usage in all types of industries and with most commonly used metals. There has been no startling development in brazing, although it can be said to have advanced tremendously because of the vast store of knowledge gained through production of products for war.

It has been again proved, for instance, that with certain types of brazed assemblies the joint is stronger than the metals joined. In other cases it was found that complex products made from numerous small stamped parts were better, stronger and much cheaper to make than by other methods. A notable example of how brazing speeded production is the trigger guard for the widely used Army carbine. Here approximately 30 small parts of simple shape are joined by brazing to form a part that formerly required a forging and then considerable machining.

Added impetus has been given the use of brazing as a process by the increased use of special tips on mild steel or cast iron shanks and bodies for cutting tools. Many methods are employed in applying such tips, but brazing is the most common.

A field closely allied with welding has also shown progress that will make it a more important factor in production. That field is oxyacetylene cutting of metals. Advances in the field now permit the accurate cutting of chromium nickel stainless steels with little more difficulty than is encountered in cutting mild steel. In cutting stainless, a flux is introduced into the oxygen stream.

Refinements in application and better cutting tips make possible the cutting of sheet steel with edges that will compare favorably with those left after rough machining. Such edges are highly satisfactory for many uses.

One of the most important steps in gas cutting is the adoption of electronic tracing devices for controlling the cutting machines. By this means, intricate shapes can be cut on production schedules through the use of easily prepared paper templates. Thus difficult shapes can be cut accurately in quantities less than those that would make feasible the making of steel or wooden templates.

Mechanical Fastening

In mechanically joining fabrications or parts there has been a decided trend that gives every indication of continuing in all fields where bolts and nuts are used. The trend is towards the use of lock nuts of several kinds. This trend has had a decided effect

New electrodes are constantly appearing for special purposes and particular material. This rod being used for overhead welding was developed for low alloy, high tensile steel. (Courtesy: General Electric Co.)

upon not only methods of assembly but upon the accuracy of bolt and nut manufacture as well. There is some difference of opinion as to the need or the value of lock nuts, but one large automobile manufacturer is planning to use lock nuts for every application where any type of nut was previously used.

Several advantages are expected from the use of lock nuts, not the least of which is a saving of $7 per car. The saving is chiefly in labor cost, as it is comparatively simple to tighten a lock nut as com-

pared to applying a lock washer and then the nut or to apply the nut and then insert and bend a cotterpin.

The use of lock nuts, especially of the type that are compressed in order that they become somewhat oval in shape, requires an accuracy of thread that is greater than ordinary. For if the threads are not accurate much of the effectiveness is lost, as the proper torque cannot be attained.

Before long, perhaps even before this issue is published, an announcement is expected giving the results of extended study of committees in this country and Great Britain to determine a thread standard for adoption by manufacturers in both countries. It is believed that the new recommended standards will combine the best features of several currently used standards.

Much has been learned about the proper torquing and loading of nuts. Research has been conducted to determine when and why nuts loosen and study is continuing along similar lines. This will give a more scientific basis for applying torque for various applications.

As a matter of fact, studies on proper torquing show that on any average bolt, the designer, the metallurgist and the manufacturer are only about one-twentieth as important, individually, as the man who actually tightens the bolt on the assembly floor. Some of the difficulty in getting nuts on tight enough has been overcome through the use of torque wrenches, which are now almost universal in use. However, good judgment on the part of the workman has been shown to be of even more value.

Tests have shown that it is sometimes advisable to tighten a bolt and nut assembly to the point where the bolt is stressed above the yield point of the material. With adequate size bolts the load is practically static, so there can be no harm in yield, providing that the plastic deformation is not so great as to reduce static strength of the bolt.

Rolled Threads

Much of the prejudice which once prevailed against rolled threads on bolts used for precise applications is being dissipated. Another automotive manufacturer is now using bolts of heat treated rod with rolled threads. It has been learned that rolling threads sets up a compressive pre-stress in the material and thereby increases fatigue durability. In fact, special rolling tools have been devised to do similar pre-stressing by hand.

During the war many aircraft bolts were elaborately made, with ground threads and extremely high finishes. According to experts in the field of fastening, the cost of this type of bolt was not justified, nor will it be in future applications in the mass production industries.

Much has been learned in the field of riveting during the war, particularly in aluminum riveting. Much of this knowledge was developed in the aircraft field and chief users of the information will continue to be in those fields.

During the lull in building construction, manufacturers of rivets for iron and steel construction have increased their knowledge of the action of riveting. Their studies have shown that cold riveting is most satisfactory for many large fabrications. Cold rivets of ½-in. dia. and larger must be squeeze driven by pneumatic or hydraulic pressure for best results. Advantages of cold riveting accrue from the fact that steady pressure on the rivet causes the shank to swell uniformly throughout its entire length completely filling the hole and accommodating itself to any irregularities in the hole surface.

Because the rivet fills the hole completely, there is no play between the rivet and the surrounding metal. The joint is solid and rigid and withstands permanent distortion up to loads far in excess of ordinary working stress in the structure.

Among the advantages claimed for cold riveting are the following: Reduced distortion, elimination of need for fuel and heating equipment, greater production and many others. Because of the type and size of equipment needed for cold riveting, this work can seldom be done on the job, but it can result in better and less expensive riveting in fabricating shops. One reason why there has not been more cold riveting in the past is that many cities do not permit construction projects to use fabrications so joined. Building codes are being revised in several major centers to permit manufacturers to take advantage of the method.

Continued Research

One certainty emerges from all the steady advancement in joining methods and that is that progress will continue through accelerated research, better engineering and a more judicious choice of equipment and methods. Among the causes that will spur progress are: Improvements in materials that will require technological development of joining methods; a continuation of the practice of breaking large parts down into sub-assemblies that must be joined subsequently; a need to produce highest quality products at the lowest possible costs; and, the increased use of composite structures in which component parts formed by stamping, forging and casting are assembled into one unit to take advantage of the best and most economical features of each method for any one application.

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Solvent cleaning can be achieved by dipping, by vapor degreasing or by emulsion. In this vapor degreasing operation, a magnesium alloy casting is being cleaned prior to an alkaline cleaning step. (Courtesy: Dow Chemical Co.)

Cleaning and Finishing

Reviewed by T. C. Du Mond

AS IN MOST FIELDS of production, activity in cleaning and finishing during 1945 centered about the further application of previously introduced methods. Too, a large portion of industry had an opportunity to try its war-found knowledge on its normal products. This latter fact gives promise of painted products which will last much longer than previously thought possible and plated equipment that will remain bright and rust-free for many, many years.

There were, of course, new products and new techniques introduced during the recently ended year, but probably the most important step forward from the standpoint of the production man—as well as from that of the eventual user—is the better choice of materials, equipment and methods and better control over the methods. Progress is apparent in all aspects of product finishing—cleaning, painting, electroplating, dip coating, chemical finishing and descaling.

There has been a considerable increase in the more accurate methods of measuring thickness of coatings in order to insure maximum service life and most satisfactory protection. Two of the latest devices for measuring thicknesses of added surfaces are based on magnetic principles. One method determines coating thicknesses by the force required to pull a magnet away from the metal which has been coated. The thicker the coating, the less is the force required to move the magnet away. The second method measures the variations in magnetic flux.

Since cleaning is preliminary to any subsequent finishing operation, let's first summarize progress in this area.

Cleaning

In precleaning of metals there has been introduced, and rather widely applied, combination solvent-alkali cleaning. Materials used combine the best features of alkali cleaning and solvent cleaning. Solutions of these materials are outstanding in saponification, emulsification, deflocculation and solvency. Lack of solvency is considered a weakness of most straight alkaline solutions and the other characteristics—saponification, emulsification and deflocculation—are missing in most solvent cleaning methods.

By using combination solvent-alkali cleaning methods most ordinary dirts, oils and greases that have not been too firmly embedded and hardened can be removed in one standard piece of equipment and with only one solution. This fact alone can solve most cleaning problems where a variety of parts coming from many types of processes must be handled with

little equipment. Also, the dangers of picking the wrong cleaning methods are practically eliminated.

Another new method of cleaning centers about a solution which uses a dry acid powder containing foaming and wetting agents and an inhibitor. The resultant solution can be safely handled under all conditions. One advantage of the material is that it does not require critical conditions of temperature and concentration. Such a solution is rapid and complete in removal of tight temper scale, brittle heat treating scale and rust.

Surface preparation for subsequent painting or for ordinary rust-proofing is generally a distinct operation, but a new cleaning material recently introduced for use on irons and steels does both at one time. Cleaning and preparing the surface for painting is speedily accomplished in one operation at rather low cost. Parts to be prepared can be processed in ordinary cleaning tanks or in spray washing machines.

Blast cleaning has been applied with great success to many products once considered too delicate to be cleaned this way. Much of the success in the method's speed has been due to the introduction of materials much less hard and abrasive than the sand originally used in blast cleaning. Among the wide variety of materials used in blast cleaning are coffee grounds, coconut shell meal, clover seed and several types of plastic powders. Hardness of the material being removed does not matter too much, for carbon is removed from aircraft engines by such methods. Use of soft blasting powders has speeded some cleaning operations greatly, because there is little or no need to mask parts for protection of critical surfaces.

In pickling and its allied processes the outstanding development has been the successful application of sodium hydride method of descaling stainless steel. Although this new process has been most frequently used on wire, it is being used quite successfully on formed stainless steel parts to remove scale formed by air quenching after annealing. Essentially, the process consists of dipping the parts into molten caustic soda containing metallic sodium. After remaining in the solution about 10 min., the parts are rinsed in water where most loose scale is blasted off by steam formation and then given a short acid pickle to remove those oxides and elements remaining. After a second water rinse the parts are put into a nitric acid pacivator bath. One company using this method reports that parts are now descaled in about 30 min., compared to the 2 to 4 hr. required by previous methods. Other advantages cited include more uniform results with considerably less metal lost.

While not a development of 1945, vapor blasting has seen a great improvement in technique and more widespread use during the last year. Vapor blasting, and its variant, vapor blast honing, has been found quite satisfactory for use on rough machined, ground and rough polished parts such as bearing races, bolts, gears, splines and instrument parts. Vapor blasting is done in much the same general manner as sand blasting, except that considerably higher speeds are used (3200 ft. tip velocity per sec.) abrasive material is finer (100, 200, 400 down to 1200 mesh) and the abrasive (Novaculite rock) is mixed in varying proportions with water and a rust inhibiting chemical. In effect, vapor blasting combines the features of several processes and operations including: sand blasting, polishing, cleaning and shot peening.

High accuracy can be obtained with fine mesh abrasives. Parts with tolerances as low as 0.0001 in. have been polished to complete satisfaction and well within specified tolerances. In cases where ultra-fine tolerances must be held, the ratio of abrasive to water is reduced.

Bars that were vapor blasted have been tested and showed an increase in tensile strength of from 5 to 10% over bars that had been polished by hand.

In most forms of cleaning there is a distinct trend toward the use of automatic equipment. Washing machines can be used with nearly all solutions, and as a matter of fact some solutions work best in automatic equipment. The practice of placing cleaning equipment in, or closer to, production lines places additional value on the cleanliness of automatic machines. Furthermore, cleaning is much more critical now than it was a few years ago. Advances in heat treating and the use of protective atmospheres make imperative the complete removal of cutting oils, drawing compounds and any other foreign matter from metal surfaces.

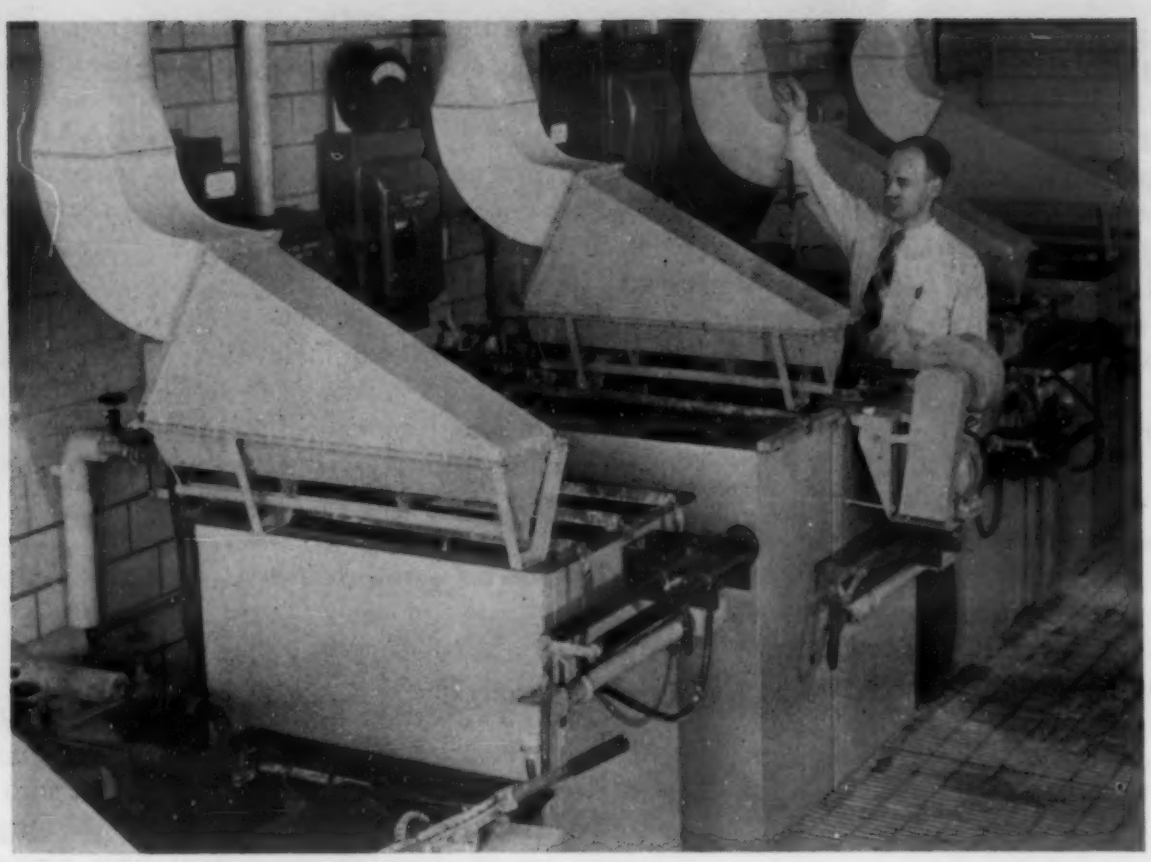
Where chemically clean surfaces are required many production men now insist upon electrocleaning, since methods have been devised to overcome former sources of annoyance such as foaming and hydrogen bubble explosions. Now it is possible to control foam blankets and prevent overflowing, fuming and explosions. Anodic cleaning permits the elimination of some precleaning operations.

Plating

Much of the attention of electroplating experts has been devoted during recent years to the plating of aluminum. Difficulty has centered about the oxide film which forms naturally on aluminum and most of its alloys. Answers to the problem have been found by pursuing rather divergent paths.

The simplest means of plating aluminum is through a process in which the aluminum is dipped in a solution which makes the surface receptive to copper or silver plating. The solution deoxodizes and deposits an alloy film at the same time. The process does not require an electric current and generally can be applied in about 1 min. Almost immediately after the dip, the aluminum part can be plated with copper or silver by ordinary electroplating techniques.

In applying tin coatings to aluminum, supersonics have been applied. In studying the effects of ultra



This laboratory type plating plant points the way to future plating plants where complete control and cleanliness are paramount. (Courtesy: Du Pont Co.)

high frequency radio waves it was discovered that they aid alloying of metals, as for instance aluminum with lead. The method has been applied successfully in putting tin coatings on aluminum with no intervening film. In effect, the radio waves cause the natural oxide film on the aluminum to be knocked off and be replaced by a layer of tin. Application of supersonics to plating are not yet general, but it is expected to become an important method in future production.

The evidence of what happens to some plated surfaces is readily seen on most of the automobiles remaining on the roads today. Chromium plated bumpers and other bright surfaces have become pitted and rusted. This condition has resulted in changes in plating specifications and has pushed the trend to better control over electroplating processes, better choice of plating tanks and other accessory equipment and the introduction of more accurate coating thickness measurement devices.

Surfaces to be electroplated are now ordered with a minimum thickness of plating rather than an average thickness as was formerly the case. In order that platers' costs do not get out of line through these requirements, considerable more control is exercised over all phases of electroplating—time, temperature, solution concentration, current density and the purity of the plating bath itself.

Bright nickel plating has come into great prominence in recent years. This has introduced new problems to the plater, because any contamination from the tank makes results far from satisfactory. Thus, tanks for bright nickel plating are now rubber lined in many cases. Such linings eliminate the chances of any unwanted metallic elements being introduced into the bath.

The automatic handling of parts to be electroplated has always been desirable, but heretofore not practical except for production runs where quantities were sufficient to justify custom-built equipment. Now, however, one company making plating equipment—and possibly more—is introducing semi-automatic equipment that can be used efficiently on moderate sized runs. Standard interchangeable racks and simplified controls over timing and other factors make possible the quick change-over of the machine for widely varying sizes and shapes of parts.

Recently there has been announced an electrolytic treatment for the protection of magnesium die castings against corrosion and abrasive action. The method of treating produces an anodized surface which is light grey, when the a.c. variation of the treatment is used, or dark green, by the d.c. variation. Other colors can be obtained by dyeing as is done with anodized aluminum.

After cleaning, parts to be anodized are connected to the electrical circuit with a magnesium—or rubber insulated steel—clamp and immersed in the tank. If the d.c. anodic finish is desired electrolytic action is through use of d.c. throughout the entire process. For the a.c. finish, a.c. is used with a high initial current density. During the course of the electrolytic process

the amperage is reduced, reaching its lowest point at the end of the time cycle. Following electrolytic action, parts are boiled in fresh rinse water and then dipped in a weak chromic acid solution. The latter dip is to provide proper paint adhesion.

Both corrosion and abrasion resistance of anodic treated magnesium are higher than that obtained by any other treatment. The only disadvantage discovered thus far is that die castings with steel inserts are not covered completely since steel causes "blanking out" in the area immediately adjacent to the insert, and leaves this area unprotected.

Organic Finishing

There has been little that is absolutely new in the way of equipment for the application of organic finishes. There has been, however, a steady development of existing types of equipment to handle the newer finishes most satisfactorily. In 1945 there was continued evidence of a decided trend toward automatic equipment of all kinds and toward a better choice of equipment to do the desired job.

The newest development in organic finishing was announced late in the fall of 1945 and is just now being applied in industry. Dimenso—as this development is known—is a novel spray gun which sprays two colors simultaneously through one nozzle. With this gun it is possible to produce two-coat spatter finishes and simulated hammered finishes in one operation. Finishes give the effect of iridescent metal.

A large number of pattern styles are obtainable with the Dimenso gun, including: Smooth finish over color, color over metallic, and a comination of metallic enamels producing hammered finish effects.

Finishes produced through the use of the Dimenso gun compare with wrinkle finishes and serve the same purpose, namely to mask or bridge metal imperfections. Such finishes are considered ideal for radio cabinets, lighting fixtures and other metal products where attractiveness and durability are desired.

The Dimenso spray gun can be used manually or in automatic equipment.

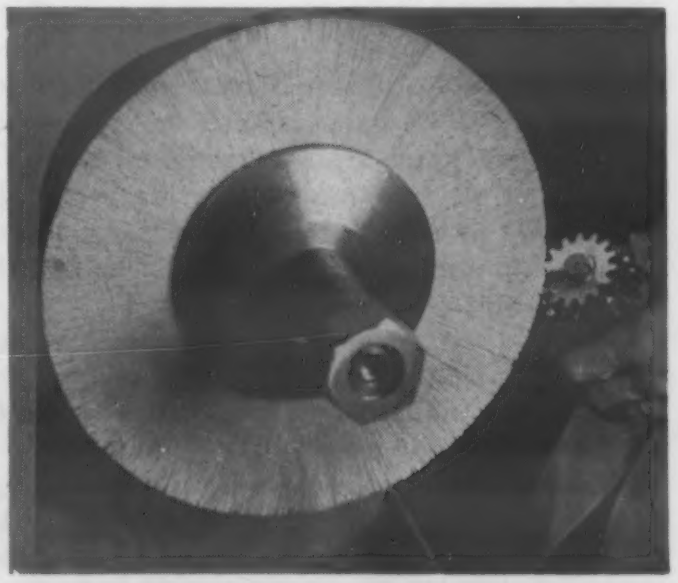
There has been greatly increased use of electrostatic methods in organic finishing. There are two variations—one to detear dip coated products and the other to insure complete paint coverage through electrical attraction. There was some opposition to the use of these methods when they were first introduced because of the supposed hazard of high voltage electricity used. The objections and prejudices have seemingly been overcome and it is expected that these methods will be widely applied in postwar production.

In electrostatic spraying, operation is based on the theory that charged particles of paint will be attracted to the grounded parts to be finished as it passes through an electrostatic field. The electrostatic field is created by setting up electrodes on both sides of the work and applying 85,000 to 100,000 volts of low amperage pulsating d.c. current. Paint is sprayed at the work at low velocity, the particles of paint are charged and the charge impels the paint globules to the work. Faster and more complete coverage of the part is thus achieved with a worthwhile saving in material.

Detearing is based on the same theories as electrostatic spraying, but is used for the opposite purpose—that of removing surplus paint, in the form of tears, from the work. Detearing is used on work which has been dipped in the paint and then drained. As the work passes along on its conveyor, it passes over a detearing electrode, operating at about 80,000 volts. The attractive force pulls off any paint dripping from fatty edges.

Automatic paint spray equipment was installed in many plants during the war to obtain the speed of production necessary to meet needs of the services. This helped to accentuate the feeling that extremely high production was necessary to justify automatic equipment. Much of this feeling has been dissipated and it has been proved that automatic machines can be economical in cases where production ranges from 100 pieces per hr. upwards. In addition to savings in time and handling, automatic spraying is said to result in more even coatings, better control and savings in material. Some automatic machines have baking ovens attached so that parts can be placed in the equipment and come out the other end painted and baked dry.

Development of new synthetics and better organic finishes have resulted in some changes in techniques that mean considerably less time and materials to achieve highly satisfactory finishes. One example given illustrates the point: On a product that formerly was lacquered it was found that a new synthetic air-dried in 11 sec., as compared to 14 sec., and the cost of the synthetic was $1.75 per gal. less. In



Wire brushes, muslin wheels and felt bobs have become increasingly important in cleaning, polishing and deburring operations.

addition the synthetic permitted better control of film thickness, was fireproof and would completely and smoothly cover a surface in two coats. The same surface finish formerly required a primer, two coats of lacquer, a water-sanding operation and then two more coats of lacquer for the final finish.

One example of the mechanization and speed-up of cleaning and finishing operations is the priming of aluminum sheets on both sides by means of a roller coating process. Large aluminum sheets are handled at the rate of 350 per hr., per 6-man crew, as compared to 18 to 20 sheets per hr. by former methods with the same manpower. The sheets travel by conveyor through an acid bath, a water rinse and then a roller coat of zinc chromate primer is applied to the under side of the sheet. The sheet is then air-floated (warm air) for about 5 ft. to let the primer dry before the sheet comes to rest on another conveyor and is fed to another set of rolls for application of the priming coat to its upper side.

Other Finishing Methods

The much greater use of stainless steel has placed considerable emphasis on methods of polishing this material. Hand polishing is difficult and expensive so it is natural that electrolytic methods of polishing have been widely accepted.

In electropolishing, the work becomes the anode (the opposite from its relationship in electroplating). A controlled electrolyte is used with a cathode of stainless steel or some inactive conductive material such as lead, graphite or Duriron. The cathode is much larger than the piece being polished, in some cases from 10 to 20 times its size and of the same general shape as the work.

In performing the polishing action by this process, the electric current forms a solid oxidation product on the surface of the work. When this oxide moves slowly away from the surface of the metal being polished, a fresh, clean layer of metal is exposed. One great value of the process is in the fact that resistance of the film to dissolution is greater in the troughs such as are caused by scratches than on the peaks. Thus the peaks are dissolved away faster than the troughs and the surface becomes more nearly plane. Through its action, the process effects not merely a cleaning, but an actual polishing, with surface refinement.

Although electropolishing is effective on any stainless steel form, its greatest value lies in polishing small parts of rather complex shape that would be difficult—if not impossible—to polish otherwise.

Dimensions of the work will change during electropolishing. A simple brightening may remove about 0.0005 in., but to obtain a good polish it is necessary to remove about 0.001 to 0.002 in. of metal. Because of the action of the electropolishing process small burrs are removed along with surface scratches.

The past year has seen a wedding of the two principal methods of drying organic finishes. For several years there has been a rather determined competition between gas fired ovens and infra-red ovens. Both methods have their own features and advantages, so some producers have combined both types of heating in one oven. Also new to the heating field is the use of the so-called infra-red gas burner in which the heat from an intense gas flame is aimed directly at the object to be dried, as would be the case with infra-red lamps.

A war development that is bound to carry over into peacetime production is the new technique of polishing and buffing which has been widely applied to many materials including plastics and most of the metals. Common practice in the silverware and jewelry fields in prewar days, the methods of using soft muslin wheels and felt bobs faced with a polishing compound found even wider use in war production. At first the method was used chiefly because of its polishing and deburring action, but it has now been learned that, properly applied, an extremely light finishing cut can be taken on metals.

One outstanding example of the method's application is an airplane landing gear piston which is buffed and polished to approximately final size before plating. During the operation approximately 0.0007 in. of metal is removed. This particular job is done on an engine lathe, with the revolving buffing wheel mounted on the lathe's toolpost. Feed and travel of the buffing wheel are controlled by the lathe's standard mechanisms. By doing the final polishing to size first and then plating, considerable time is saved, not only in the time formerly required to plate oversize but also in eliminating the grinding down of the oversize plated surface.

During the war anodic and chemical coatings were applied to many aluminum products, primarily for the protective value of the finishes. Now the same methods are being used with dye coatings to add eye appeal to the products. A wide range of colors is available including reds, blues, greens, yellows and blacks. After being dyed the parts are given a sealing and dye fixing treatment which usually consists of immersing the parts in a nickel acetate bath and then a 1% sodium dichromate solution.

It is the general feeling of a large part of industry concerned with finishing that the buying public, whether it be purchasing consumer goods or capital goods, will be much more particular about the type and lasting quality of the finishes supplied them.

The editors wish to express their appreciation to the following for the courtesies extended in supplying information on which this article is based: American Chemical Paint Co., The Enthone Co., The Lea Manufacturing Co., Monroe Calculating Machine Co., National Bureau of Standards, Pennsylvania Salt Mfg. Co., The Sherwin-Williams Co., Vapor Blast Manufacturing Co.

Testing equipment varies in size and complexity from small lights to extremely large X-ray units. Here a young lady is visually inspecting filaments for lamp bulbs. (Courtesy: Westinghouse Electric Corp.)

Testing and Inspection

Reviewed by Harold A. Knight

FOR THE FIRST TIME metal fabricators were talking in terms of a millionth of an inch whereas they had previously been satisfied with thousandths or tenths of thousandths. Aircraft, radar and other forms of war manufacture demanded precision of a type not previously envisioned. Hand in hand with precision had to come speed of production. Again, allowances must be made for the high dilution of skilled labor.

The importance of surface smoothness was realized as never before as smoothness theoretically provides no starting point for incipient cracks. However it was established in 1945 that surface smoothness is not necessarily a must—thus shot peening leaves a surface anything but smooth, but is better for certain stressed parts than would be a smooth surface. Surface measuring became highly developed in 1945. Stress-strain indicating an analysis has attracted much attention, with simple measuring devices developed.

The large number of returning blind veterans was the inspiration for an electronic sound gage, based on three tones of notes issuing from the loud speaker, corresponding with red, green and orange lights on the corresponding visual indicator. One of the newest electronic devices is a 20,000,000-volt "betatron" that enables engineers to take pictures through 15 in. of solid steel. In fact the X-ray was another solely laboratory tool that came into the shop. For hardenability testing new fixtures for holding the samples have proved an important adjunct.

A novel development is the measurement of substances during heating and cooling, thus establishing amount of expansion and contraction. Such an instrument is the "Interferograph," that automatically records by a photographic process measurements of minute dimensional changes in most substances. It records changes on 35-mm. film. Its first applications have been for dental materials and base metal of enamelware. It was developed by the Bureau of Standards.

For determining high temperature properties of

new alloys, Westinghouse has developed two new creep-test instruments, especially intended to evaluate alloys used in furnace construction. The creep-to-rupture test was selected as the most suitable means.

One of the tendencies has been to simplify mathematical processes, making the gage do more and more of its own calculating. Thus a fixture to hold tapered parts in a measuring machine was devised at the Pittsfield works, General Electric Co., that simplifies checking of tapers per foot and eliminates the necessity of a long mathematical process for each part. In fact after a simple reading or two the angle of taper per foot can be found in any machinist's handbook.

Electric and Electronic Inspection

The electronic type instruments are almost as modern as the atomic bomb, contributing super-accuracy and super-speed. Often they perform services previously difficult or impossible and often hazardous. Instruments give accuracy instantly, with no delays due to the pointer wavering or overshooting. A weight-load indicator weighed loaded airplanes to ensure it carried its maximum potential in fuel, bombs and cargo, with weight distribution correct.

Another interesting instrument is a new electronic micrometer, able to measure motions of one ten-millionth of an inch. The new instrument was developed by G. M. Foley, Battelle Memorial Institute (many readers are doubtless familiar with the earlier electronic micrometer of R. W. Carson) and was designed to test performance of precision lathe spindles. The micrometer can magnify by 10,000 times the inaccuracies of the spindle and produce on an oscillograph a visible pattern of effects of changes. The instrument is a miniature radio station whose frequency is varied by changes in the spindle's position. It is also used to make a high speed dilatometer to follow the crystalline changes in steels during rapid heating.

One of the ticklish bits of manufacturing was of the gyro-compass for Navy ships by Chrysler. When the 50 lb. bronze rotor is spinning at 6000 r.p.m. the rotor must be in perfect balance. In testing, every disproportion was registered on a screen by the rapidly moving finger of an electronic device, the cathode ray oscillograph, which reported the condition and pointed out the location.

Speaking of the electronic gage, one company says: "This is an instantaneous, extremely sensitive method, having great magnification. It should be used for very accurate comparative or selective inspection."

Supersonics—the use of ultra-high frequency radio waves—is emerging as a potentially important inspection method for the non-destructive testing of materials. Small voids, cracks and inclusions in both metallic and non-metallic materials can be detected through changes in density or changes in modulus of elasticity. The sonic method is particularly applicable to materials having a constant cross section, such as those resulting from rolling or extruding. Satisfactory tests have already been made on aluminum, phosphor bronze, beryllium copper, brass and other metals as well as plastics and other extruded materials.

There is a possibility that the sonic method will be used in rolling mills to check soundness of the metal at various stages, or at least immediately after the metal leaves the pickling tank.

Spectrography

Spectrography is "taking hold" with rocket speed. Take the experience of the Fairchild Engine & Airplane Corp. In their laboratory a chemist and his assistant have checked as many as 75 samples for from 8 to 10 elements in an 8 hr. work day, which to do by ordinary chemistry would require a large staff and much equipment. By chemistry it would take two days to measure quantitatively molybdenum in a steel alloy; with a spectrograph he can do it in 30 min. and with better results.

International Harvester Co. reports that the most significant development of the year is the Dietert two-meter instrument, which offers dispersion as high as 3.4 A deg. per mm. in the first order and other features increasing accuracy and flexibility. But they comment: "However, light-actuated exposure control such as we have been using with great success for over two years is still not provided and, as far as we know, is nowhere available commercially."

An instrument which electronically measures the concentration of elements in alloys and automatically records the results has been developed by J. L. Saunderson and co-workers at the Dow Chemical Co. This direct-reading spectrometer, as it is called, has been in use in the company's magnesium alloying plant for several months, where alloy analyses can now be made in 40 sec., a fraction of the time required when using the standard spectrograph. The substitution of an electronic method of measuring the intensity of spectrum lines eliminates the necessity for photographic and developing equipment and an expensive microphotometer, and avoids the errors commonly encountered due to film variation. Girl operators can be trained in a single day to use the instrument efficiently. The entire operation is fully automatic from the time the metal samples are placed in the instrument until the analysis is recorded on paper. Up to 14 elements can be determined simultaneously.

The development of the direct-reading spectrometer will be significant in all the metalworking industries, and in any chemical process where close and constant spectroscopic control is desirable. In melting, alloying and casting of metals it will lower costs by reducing the time a melt must be kept at temperature while waiting for analytical reports. Accuracy is equal or superior to that possible by spectrographic methods.

Magnetic Inspection

Until recently regular commercial a.c., properly transformed and regulated, or straight a.c. from storage batteries or full wave 3-phase rectifying systems, were the two main types of current used to magnetize parts. Magnaflux Corp. has now developed equipment delivering half-wave, single-phase, rectified current for magnetization and find that it offers certain advantages. Use of the equipment delivering such current permits easy detection of deeper sub-surface discontinuities, provides greater mobility of the inspection medium with easier formation of indications, and allows more economical construction of equipment.

Perhaps the most significant accomplishment in the field of magnetic particle inspection is the development made in the engineering and manufacture of specialized and automatic equipment. Labor cost has heretofore been the dominating expense in the use of magnetic particle inspection. Automatic conveyor and specialized equipment have allowed reduction of the cost of inspecting some parts to as little as a small fraction of 1 cent.

Some of the applications for which automatic equipment has been designed and built are the inspection of resistance welded pipe, automotive parts, and Ordnance projectiles.

In the variation of magnetic particle inspection, called the wet method, the inspection medium used consists of ferro-magnetic particles prepared in the form of a paste and then mixed with a suitable oil at the time of use to prepare a suspension. Magnaflux recently developed a new paste formula which offers several advantages and will soon be available commercially. It provides a much better suspension and does not age during storage.

For the inspection of large castings and forgings, equipment delivering very high output is needed. Magnaflux units delivering as much as 15,000 amp., low-voltage d.c. have been designed, built and put into service.

Another non-destructive testing method is fluorescent penetrant inspection which is used to locate discontinuities open to the surface in all solid materials, particularly non-ferrous metals, ceramics, plastics, and glass. Zyglo equipment and materials are used in the application of this method. Parts to be inspected are wet with a special fluorescent, penetrating liquid which is allowed to seep into discontinuities. The excess liquid is then removed from the surface of the part. Next a developing agent to draw the fluorescent liquid back out of the discontinuity is applied. Upon examination under suitable near-ultraviolet light, discontinuities are revealed by a line of bright, greenish yellow fluorescence.

The year 1945 has seen much progress in the development and manufacture of automatic conveyor equipment for the magnetic inspection of parts. The use of such equipment involves a minimum of time and labor and permits use of the method for many inspection problems in which very low cost is an extremely important factor. Some of the problems solved have been the low cost inspection of automotive, aircraft, and ceramic parts.

One recent accomplishment in the field of fluorescent penetration inspection has been the development of a special penetrant for the inspection of ceramic insulators. It is important that the dielectric strength of the somewhat porous ceramic not be affected and a special penetrant which is completely driven off by application of heat and has no residual effect on the dielectric strength of the insulator, is now available.

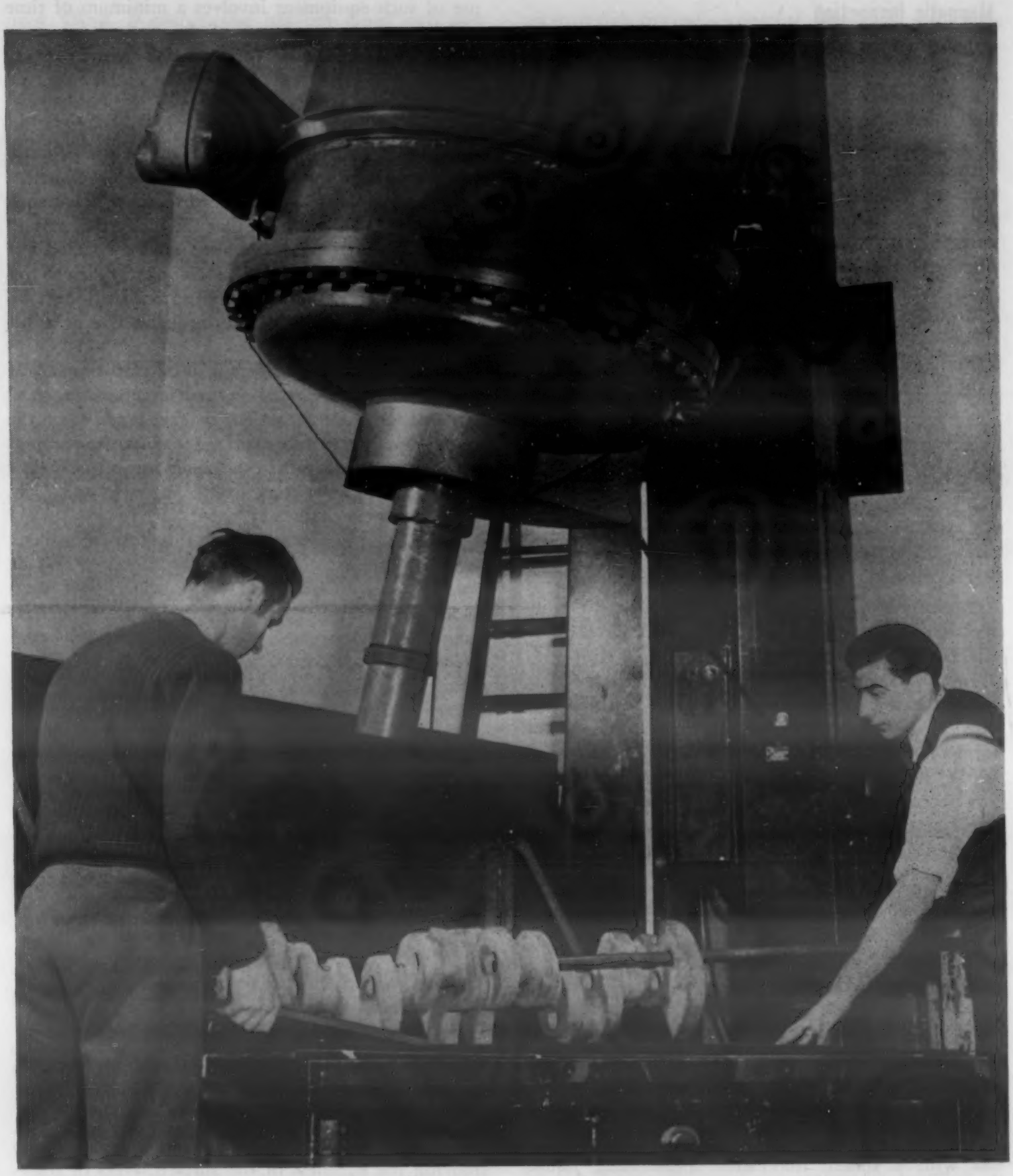
Alnico horseshoe magnets have by now been made so strong that they are being used for inspecting castings and welds for flaws. The magnet is placed on the underside of the surface, with the magnetic sprinklings on the upper surface. It can handle metal thicknesses up to 1 in. The magnet is 2½ in. wide and 3 in. high, with pole bases ¾ x ¾ in.

Another type of inspection in this class is magnetic analysis inspection which usually functions at the source—the steel mills and rough inspection departments of aircraft engine manufacturers. It detects flaws like cracks, seams, laps, slivers, pin holes, weak welds, cupping; also mix-ups in analysis, grades, processing, heat treatment, hardness and structure. Improved test methods and measuring circuits will show up in equipment scheduled for next year at which time the method can be extended to new fields.

Hardness and Hardenability Testing

The general trend in production hardness testing leans toward testing the semi-finished and finished products with light loads, such as used with the "Rockwell" superficial tester. This requires less material to be removed in final grinding or finishing, if it is necessary to remove the indentation. On hard steels the depth of indentations with the "Rockwell" superficial tester is less than 0.001 in. when using the 30 kg. load against a depth of indentation of 0.0035 under C scale conditions of test on the normal "Rockwell" tester.

The research metallurgist has been interested in studying the hardness of the surface layers of materials with even lighter loads than were formerly available. This requires a very sensitive and accurate indenter and the Knoop indenter, invented at the National Bureau of Standards, opened a new approach to the related problem of microscopic impressions for studying the hardness of constituents of metals. The "Tukon" tester, redesigned to include a microscope and a special mechanical stage, was made available for this work with the relaxing of priority control of critical materials. Micro-hardness testing is in its in-



This engine crankshaft casting is being positioned prior to being radiographed by a million volt X-ray unit. (Courtesy: Ford Motor Co.)

fancy and many interesting papers and much valuable information should be available shortly.

There is a decided tendency to develop gages and instruments, for measuring specific qualities and quantities, that are extremely complex and in many cases rather expensive. Two instruments built under these conditions for the anti-friction bearing industry are the Race Tester and the Anderometer. Both of these instruments reached a point of standardization within the last year and both measure surface waviness. The Race Tester measures surfaces of bearing races on a production basis and is useful in setting-up race grinding and finishing machines and in inspecting races before final assembly.

The Anderometer inspects completed ball bearings and measures surface irregularities and deviations from circularity of balls and races. Several thousand ball bearings can be inspected daily in this manner with each instrument.

Strain Gages

Much attention was being paid to stress-strain gages in 1945. One well-established method is by applying a brittle lacquer to the unloaded part. Then cracks visible to the unaided eye will show at right angles to the direction of stretch when the lacquered part is stretched five hundredths of 1% of its length in any direction. Since the number of cracks per in. of lacquer is proportional to the percentage stretch, one can observe quickly the location, magnitude and direction of the deformation produced at the surface of a part by a load. Such testing has been particularly applicable to aircraft, where the saving of 1 lb. of weight is worth up to $120 to the airline operator.

The main problem has been the development of suitable coatings. Those now used are sensitive to changes in temperature and humidity and must be used under fairly constant conditions. However, extensive work is being done to develop coatings less sensitive to weather and present prospects seem very good. A recent advance in this field has been coating of parts with latex to protect them from oil and permit testing under actual service conditions. It is usually necessary to simulate actual service conditions in the laboratory.

The electric resistance strain gage certainly is not new, but the end of the war has released a great store of information on this most versatile strain detector. Practical applications of the SR-4 strain gage are unbelievably numerous, and present a fascinating appeal to the experimental engineer. In the field of dynamometry, these gages are doing a most spectacular job, making possible accurate, inexpensive indication of either static or dynamic loads of almost any nature. A recently developed fatigue machine makes typical use of these gages to maintain constant force. The strain indication from the gage, through an electronic circuit, controls a Thymotrol motor automatically maintaining the testing force.

The electric strain gage depends on changes in the electrical resistance of metal when it is stretched and squeezed. It usually takes the form of a series of loops of very fine wire cemented to a thin paper membrane which in turn is cemented to the surface of the part to be analyzed. A surface deformation of five ten thousandths of 1% of the length is measurable. Instantaneous variations in strain can be observed. It has been applied at several points of interest on the crankshaft of an internal combustion engine while in operation. This system is used in place of the brittle lacquer method where greater analytical precision is needed, especially at the point which the brittle lacquer analysis has shown conditions to be critical.

It is stated by experts that the present electric strain gage is too slow and some important improvements are in the offing. We have before us means of better and cheaper testing if we assemble existing techniques. The rapid routine determination of such values as area of test specimen, per cent elongation and per cent reduction of area call for the development of other simple bench devices, probably electrical, which require only one motion by the operator for each. It is predicted that a combination of electronics and wire strain gages will provide for the specimen to be thrust between two fingers, the value for area to immediately indicate itself on a dial. The broken specimen can similarly be placed between two snap fingers and per cent elongation indicated directly on a dial.

In many plants stress-strain curves were made on every test, hence the need for an electronic high magnification recorder. It is of three parts: Extensometer for tension or compressometer for flexure or compression; the amplifier with electronic controls and the recorder where the stress-strain curves are produced. The measuring system is essentially a self-balancing nul system and the energy used to perform the recording is not derived from the specimen, hence ideal for producing stress-strain curves. It is provided with magnifications of strain of 500, 1000, or 2000 in in. per in. of gage length.

Many tests require stress-strain curves in compression and flexure. Up to this time, and currently, the practice has been to use a dial gage and then plot the readings on chart paper. However, this procedure is time consuming, requires several operators, and has other disadvantages and errors. Therefore, equipment was developed which can be conveniently used in combination with the electronic recorder for producing stress-strain curves. In addition to recording compression strains, the instrument is also used for flexure or transverse tests. It can record crosshead travel or it can be attached to compression specimens at definite gage lengths. The following magnifications can be provided: 125, 250, 500, 1000 and 2000.

Another characteristic of metals, which it has become necessary often to evaluate, is the "creep" property. An electronic load holder has been developed which holds loads constant for any desired length of time. Used in conjunction with the electronic recorder "creep" stress-strain curves can be produced.

Surface Measurement

Surface roughness, or smoothness, is another physical property that often has to be measured. At the start of the war mass production methods for obtaining fine finishes had invaded many new fields of civilian production, such as refrigerators, business machines and sewing machines. Watches, formerly with hand-polished parts, are now made by special

machines. Even plowshares are often superfinished. Naturally degree of smoothness must be measured and there are two well known machines that measure in millionths of an inch.

The modern method of measuring surface smoothness is by photometric measurement which is more rapid than the older light-slit and stylus methods. Photometric measurement is based on the ratio of the photo-electric current with light-ground to that with dark-ground illumination. The photometer can measure polished test pieces that are beyond the capacity of the light-slit method.

During 1945 there was introduced a complement machine for the original surface analyzer for checking rougher surface finishes and waviness in metals, glass, plastics, plated and painted materials. The new pickup and drive head accurately measure irregularities from 100 to 3000 microinches, peak to valley, thus extending the range of the analyzer from 1 to 3000 microinches.

Speaking of surfaces, an improved machine for determining wear or abrasion resistance was introduced in 1945. It is equipped with an illuminated magnifier. The results of tests are reported either as to the number of "wear cycles" or as "loss in weight" when weighed on a precision laboratory balance.

Radiography and Metallography

Million volt X-ray units in war plants checked in 16 min. the same total of steel parts that required 60 hr. with devices used before the war. The 2,000,000 volt unit, perfected in the later stages of the war, inspected steel sections up to 12 in. thick in less than 1 hr., compared to a week with the 1,000,000 volt tube. X-raying of airplane propeller blades speeded up inspection time by 300%.

Details were released late this year of the 20,000,000 volt "betatron," used for more than a year in a government arsenal and sponsored by the University of Illinois and Allis-Chalmers Mfg. Co. It generates X-rays more powerful than any ever before used in commercial radiography, taking pictures through 15 in. of solid steel. It can be handled as easily as the low voltage equipment familiar to industrialists or the medical profession. The electrons quickly reach a speed approximating that of light and continue to gather energy as they spin about in an intense magnetic field. At length the stream of spinning electrons is diverted to strike a metal target, producing the high intensity X-rays. The machines are operated by push button and have automatic controls for timing photographic exposures. Indications are they will play an important part in nuclear physics, including cosmic ray and atomic research.

Timing of photographic exposures is now applied to almost any type of X-ray. It is a photoelectric X-ray timing device that enables technicians to obtain uniformly dense photofluorographic exposures with an overall increase in operating efficiency of 100%. The device times each exposure properly, quickly and automatically. It measures the light leaving the fluorescent screen on which the X-rays cast the object image. The photoelectric tube that scans the screen actuates a relay, opening the X-ray circuit and terminating the exposure. Previously, many variables made it difficult to obtain uniform film exposures.

An interesting application of the year was the measuring of metal thicknesses radiographically. A set of blocks of known thickness is X-rayed simultaneously with the metal object of unknown thickness. Results depend upon precision of equipment and care of the operator. The method was applied to hollow steel propeller blades—it can also be applied to plate, tubing or strip. The principle depends on the fact that the thicker the plate is, the more the X-rays will be absorbed and the less the X-ray negative will be affected by the rays passing through the material.

A new microscopy was developed during the year, described as so simple it could have been developed 25 years ago. It is an application in the cold worked state of metals, involving recovery, recrystallization and precipitation hardening. One can map out the distribution of strains over the surface and throughout the interior of a crystal by observing the internal structure as revealed by X-ray reflections.

It is confirmed that strains along the slip planes of rock salt increase the reflecting power and produce lines in the images. In this new microscopy single crystals of silicon ferrite were investigated. As a result there is no doubt that local distortion does exist along the planes where slip has occurred, the distortion resembling the rotation of crystal fragments. One can measure the amount by which the lattice at a slip line is rotated or bent. This method differs from analysis by an ordinary X-ray or electron diffraction pattern. Here a picture is obtained of the individual crystal or grain being identified; an ordinary powder diffraction pattern is the sum of reflections from all phases present. Here equally oriented particles can be identified.

(We gratefully acknowledge assistance in the preparation of this article from the following: L. R. Rothenberger, DoAll Co.; J. A. Harrington, Savage Tool Co.; Howard Scott, Westinghouse; K. E. Glover, Magnaflux Corp.; Robert S. Strimel, Tinius Olsen Testing Machine Co.; T. Zuschlag, Magnetic Analysis Corp.; F. G. Tatnall, Baldwin Southwark Div.; E. C. Shultz, Pratt & Whitney; V. E. Lysaght, Wilson Mechanical Instrument Co., Inc.; A. E. White, University of Michigan; Robert Barton, Foxboro Co.; Sheffield Corp.; Continental Machines, Inc.; General Electric Co.; Allen B. Du Mont Laboratories, Inc.; Federal Products Corp.; Precision Scientific Co.; Brush Development Co.; Taber Instrument Co.)

Instrumentation and Process Control

Reviewed by Harold A. Knight

INDUSTRIAL INSTRUMENTATION and control systems are much like the nerve system, brain and muscles of the human body. The nerves flash a message requiring action to the brain, whereupon the brain orders and actuates muscles to properly respond to the situation. In industrial instrumentation uses, thermometers, pyrometers, photoelectric cells, etc., are used for scouting conditions. Electronic or mechanical brains then actuate levers, valves and other industrial "muscles."

New developments and improvements in the industrial instrument field can be broken down into four major categories, namely:

1. Development and improvement of electronic instruments and their application for recording, indicating and controlling an increasing number of processes.
2. Improvement and development of industrial instrument accessories for electrical applications.
3. Marked advances in design, accuracy and use of flow meters and liquid level meters.
4. Standardization of thermometers and pressure gages.

Included in the electronic class of instruments, designs and developments were: Instruments for 50-cycle operation; equivalent scale type precision indicators; the pH line, applied to spectrometry; tachometers; fast speed air-actuated circular chart controllers; skip-print on multiple recorders; fast speed strip chart recorders, mercury switch controllers.

New accessories for electrical equipment include: new cast iron protecting tube; addition of new molten steel, platinum thermocouple; new glass tank crown block and improved glass tank thermocouple, etc.

The flow meter and liquid level meter improvements included: Double range mechanical flow meter and an increased group of range tubes on 6,000 lb. electric meter bodies.

Improvements announced and still to be released include: Improved electrodes for size box control; new conoflow diaphragm motors, improved external control bypass; a glass feeder control system; an adjustable indexet, and others.

In instrumentation and control the chief drawback in all these years has been lag, or interval between the time the critical condition has been reached and the time the control starts its work, a condition familiar to every householder with a domestic furnace thermostat. However there has been devised a vacuum tube thermocouple which anticipates changes in electric furnace temperatures and increases the sensitivity and response of conventional temperature controls by 1000%.

Anticipating Furnace Control

The instrument consists of two thermocouples of different thermal capacity and an electric heating element, enclosed in an evacuated glass envelope to cause heating of the thermocouples by radiation, to minimize room temperature effects and to prevent deterioration of the elements. Anticipated and corrective steps are taken to minimize the cyclic swings of most controls.

One heat treat furnace varied over a range of 50 F with conventional controls, but with this new anticipator the variation was only 5 F. In this new instrument the two thermocouples are connected in series so that the polarity of the couple with less thermal capacity is additive and the couple with greater thermal capacity is subtractive with respect to the furnace couple. The heating element is energized by the power source connecting the control mechanism and the relays that operate the main power contactors. Thus, the furnace and instrument heating elements operate together. The two couples in the instrument are equidistant from the heater, but the element with the lesser thermal capacity reacts first to changes in heater element temperature.

When the two couples in the anticipator are at the same temperature, the voltage from the control thermocouple to the control mechanism is constant. At the time that the control thermocouple institutes a change in control current starting the heating part of the cycle after having been off, the change is felt first in the two thermocouples in the anticipator.

However, the thermocouple with the lower thermal capacity heats faster than the other and the thermocouple voltage at the temperature control mechanism is increased. This increased voltage causes the controller to change to cooling, thus preventing the furnace temperature from overshooting the maximum.

Should the line voltage dip (or rise), the instrument heater reflects this change much more quickly than the furnace heating elements and the control is

properly energized to correct for the power variation before the need is recognized by the thermocouple in the furnace.

Pyrometers

The first practical and accurate way of measuring temperatures of molten steel up to 3200 F in an electric arc melting furnace has been developed and put to everyday use in the melting department of the Rustless Iron and Steel Corp. at Baltimore. By adapting and improving upon a British device, metallurgical engineers at Rustless devised a platinum thermocouple pyrometer which measures the temperature of a steel bath before the heat is tapped from the melting furnace, the reading being recorded by an electronic instrument.

The new pyrometer goes a step beyond its predecessor, the optical pyrometer, which was limited to the measurement of temperature when the liquid steel was visible in the open and being poured. The Rustless device measures the temperature of the heat of steel in the melting furnace—even though the steel is covered with a layer of slag—at a time when steps can be taken to regulate and control the temperature.

The development makes possible improvement in the quality and uniformity of the company's stainless steels. The pyrometer consists of the two interchangeable parts, an immersion head (a platinum and platinum-rhodium thermocouple encased in a fused silica tube mounted in a block of graphite) and a handle which is a 12 ft. insulated pipe containing the wires leading to an electronic recorder. The design of the equipment and its operation is such that the platinum wire and the other materials used in its construction are not destroyed.

The operator of the Rustless device simply manipulates the immersion head, mounted on the pipe handle, through the door of the electric furnace and dips it into the steel bath. The exposed tip of the silica tube, which contains the platinum thermocouple wires, is immersed in the bath and the graphite block is in contact with the metal, the slag layer and the hot atmosphere of the furnace. The whole operation, which is automatically recorded, takes 45 sec.

The instrument by which the measured temperature is recorded is equipped with a large pointer and dial calibrated in degrees Fahrenheit. This recorder is mounted conveniently near the furnace where it is easily visible to the melter responsible for the manufacture of the steel and to the man operating the thermocouple.

The Rustless thermocouple, making possible the accurate measurement of steel temperature, today provides the steel melter with the means of accurate control of one of the most important variables in the manufacture of steel. The practicability of the device, working as it does at temperatures so high that most materials are either softened or completely destroyed, lies in the speed with which the equipment measures and records the molten steel temperature. The electronic instrument responds so quickly to the temperature of the thermocouple that it is possible to immerse the unit into the molten steel, at temperatures as great as 3200 F, obtain a reading of the temperature and remove the equipment from the melting furnace before the device is destroyed or melted by the intense heat.

A "quick immersion thermocouple" has been described for special uses in such metals as 14% manganese steel where accurate temperature control is necessary and where vapors and fumes seriously interfere with the use of optical pyrometers. One of the features is that temperature measurements with it have been made 30 in. below the metal surface and are made regularly at 24 in. below. The thermocouple wires are insulated in a thin twin bore silica tube that is pulled through a nickel tube. A carbon block and fire-clay protective coating are used at the working end.

Other Controls

An important new control of the year for the foundry is the "electric eye" control of pouring. By conventional methods molds are poured by a manually-operated buggy ladle handled by an operator subject to intense heat from the iron and occasional burns from iron splash. A photoelectric control whereby the operator can work from a remote station, controlling the pouring of several ladles simultaneously was recently announced. When metal is flowing into the molds and as it reaches the riser a brilliant light is thrown off—a signal to the "eye" that the mold is full. The ladle drops back and pouring stops. The "eye" detects minute changes in light intensity. It can also indicate and control the density of gases and turbidity of liquids. It can detect an interface between two liquids differing slightly in translucency.

A new pressure recorder measures pressures up to 50,000 p.s.i., the measuring element being a cell that is tapped into the line or vessel where pressure is to be measured. The related temperature recorder, with 24 or more measuring systems taking temperatures at various points (as in a multiple effect evaporator, or a heat exchanger) will automatically start itself each hour and, in 5 min., record all these temperatures on its chart. A multi-point temperature recorder completes in 90 sec. a whole cycle of measurements. The scanning indicator can accommodate as many different systems as may be desired.

(For help in preparing this article, the following are deserving of mention: Hank Cabot, in behalf of Brown Instrument Co.; A. L. Feild, Rustless Iron and Steel Corp.; F. I. Lackens, The Hays Corp.; Westinghouse Electric Corp.; Ajax Electric Co., Inc.; Photoswitch, Inc.; and Foxboro Co.)

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

With this issue, MATERIALS & METHODS inaugurates a letters department devoted to the interchange of ideas among readers, elaboration on topics previously discussed, and—where necessary—corrections of fact in published material. In those cases where comment on the part of MATERIALS & METHODS' editors is deemed helpful, such comment also will be published. The editors, in launching this new department, hope it will prove of general interest and earnestly invite participation on the part of everyone.

Malleable Irons

To the Editor:

In your June, 1945, issue we were interested to note the Engineering File Facts, No. 82, on Malleable Iron. Many of the statements made in this data compilation are incorrect and we should like to call your attention to them.

1. Table IV. Under Alloy Malleable Iron, physical properties are given as 120,000 p.s.i. ultimate, 95,000 p.s.i. yield, 65% elongation. The elongation figure is obviously a typographical error and should be 6.5%.

2. Table II shows maximum as well as minimum physical properties for A.S.T.M. A-47-33 Malleable Iron Specification. This specification should include only minimum specifications—namely, tensile strength, 50,000 p.s.i., yield point, 32,500 p.s.i., elongation 10%.

3. Table I indicates a difference between pearlitic and spheroidized malleable iron. A structural differentation between these materials has never been recognized, both being classified as pearlitic malleables.

4. Incorrect reference to only one company as a producer of Certified Malleable Iron. The trade name "Certified Malleable Iron" is owned by the Malleable Founders' Society.

5. Table I states under "Heat Treatment" that malleable iron can be cooled at a rate of from 10 to 30 F per hr. This is incorrect in that a cooling rate as high as 30 F per hr. through the critical range will not produce standard malleable iron.

6. Under Z Metal, in Table V it is stated that ranges of strength and hardness "as cast" are available, inferring that annealing is not necessary.—This is incorrect.

7. Supermal is listed as being made by Jefferson Manufacturing Co. This special malleable iron is made by Jeffrey Mfg. Co.

8. Yield values listed in Table IV under ordinary and pearlitic malleable iron are too low, being even lower than the minimum A.S.T.M. values. The footnote reference to these values as A.S.T.M. averages is even more misleading. The correct yield point values should, of course, be 32,500 to 35,000 p.s.i. minimum, for the grades referred to.

Very truly yours,
C. F. Lavenstein,
Chairman Technical Council
James H. Lansing,
Consulting Engineer

Malleable Founders' Society
Cleveland, Ohio

It is unfortunate that so many errors crept into Engineering File Fact No. 82, as we pride ourselves on the accuracy maintained in this department. Because of the errors, it is our intent to publish a new Engineering File Fact on Malleable Iron sometime during 1946. We advise our readers to be on the lookout for this so their files can be brought up to date.—The Editors.

(Continued on page 157)

The modern facilities developed for the production of N-A-X Armorplate are now meeting peacetime requirements

Designed and installed for the production of N-A-X Armorplate, this special heat-treating unit gives Great Lakes Steel Corporation facilities for supplying you with alloy sheets and plates fully heat-treated (quenched and drawn) to a wide range of high physical properties, constantly uniform in hardness and flatness. Pre-heat-treated N-A-X alloy sheets and plates can be supplied in thicknesses of ⅛″ to 1″; in widths of 6″ to 72″; and in lengths up to 336″. For complete information, write:

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UNIT OF NATIONAL STEEL CORPORATION

CONTENTS NOTED

Continued from page 155

"Malleabrasive"

To the Editor:

We very much enjoyed reading the article on "Shot Peening" in the October issue of your publication.

However, we would like to point out that in the article, mention is made of "mallabrasive." This name should be spelled "Malleabrasive." This is a patented product produced by the Globe Steel Abrasive Co., which is a subsidiary of the Pittsburgh Crushed Steel Co.

Yours very truly,
William H. Skirble
Pittsburgh Crushed Steel Co.
Pittsburgh, Penna.

World's Fastest Aircraft

To the Editor:

Refer to your September issue, col. 2, page 646: "Fastest Aircraft in the World." Well, well! How you Yankees love to talk. I rather think it'll be a long time before you get ahead of old J. Bull. [Mr. Leslie enclosed a copy of an Australian clipping reporting a speed of 606 m.p.h. by a British plane.]

Yours truly,
E. Leslie
Melbourne, Australia

At the time this news item was prepared, United States Army authorities were certain they had the fastest plane, but soon thereafter a British Meteor set a new speed record. However, Gen. H. H. "Hap" Arnold hints that before he retires from the service in the near future, we will have the world's fastest planes in all categories.—The Editors.

Cerium Alloys

To the Editors:

I read with great interest the article on "New Uses for Cerium" by G. Ahrens, which appeared in your September, 1945, issue. The author seems to believe that the use of cerium to increase the creep strength of magnesium alloys is a German invention.

It would probably be of interest to you to know that I proposed to the I. G. Farbenindustrie in 1923 the addition of cerium to magnesium and magnesium alloys, and I showed that such alloys display a considerably improved hot hardness which makes them suitable for automotive pistons. Such pistons were made at my instigation by pressing and extruding magnesium alloys with up to 6% cerium, and their good creep strength was fully confirmed.

I applied for a German patent which was filed Oct. 25, 1923, under the number B111,588, and I named a Mr. Beielstein, an employee of the magnesium department of I. G. Farbenindustrie, in Bitterfield, as my representative for the German Patent Office. I dropped the application after it had been accepted by the office because use of as much as 6% cerium or "Mischmetall" seemed prohibitive for automobile pistons. This proposition looks quite different today because of the particular demands of airplane motors, which warrant the use of more expensive alloys.

W. J. Kroll
Albany, Oregon

Article Presentation

To the Editor:

This is a suggestion for improving the usefulness of your magazine. In general, the writer finds it to be the most interesting and informative he reads; however, he finds himself disturbed at times because one important article will start on the back of another. This means that one of the two articles must be sacrificed when clipping. It is suggested that special consideration be given to starting every article on the right-hand page and to filling the left-hand page with news notes, ads, etc., if needed.

Very truly yours,
A. F. Gagne, Jr.
Development Engineer
Pompton Lakes, N. J.

We understand Reader Gagne's problem and whenever possible try to start articles on the right. However, not all magazine readers agree with the ideas set forth. Many readers violently object to sprinkling ads and even short editorial notes among the longer, more important articles.—The Editors.

Kanthal Alloys

To the Editors:

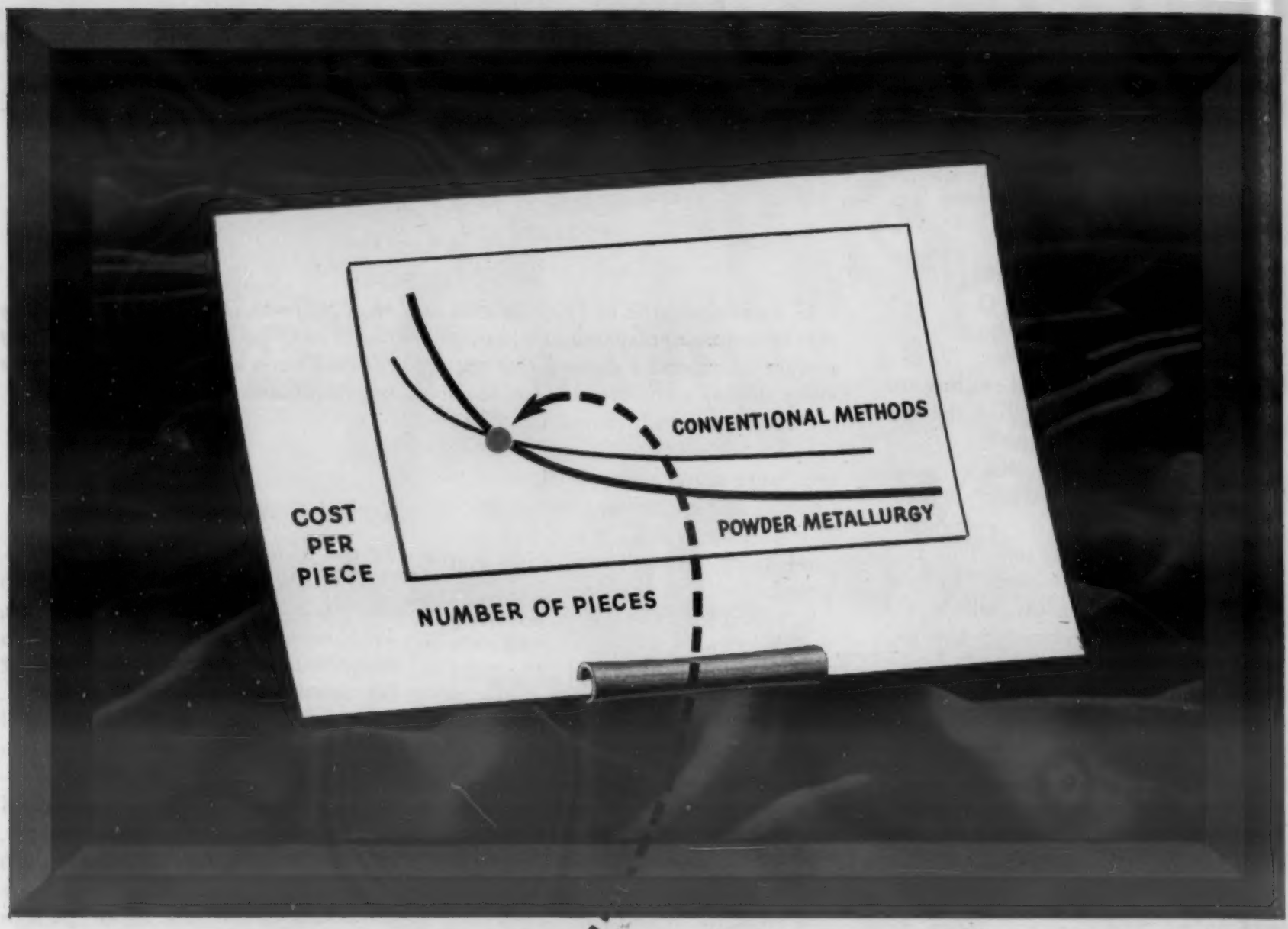
We want to draw your attention to an article published in your March, 1945, issue covering materials for high temperature service (MATERIALS & METHODS Manual No. 4).

Resistant materials are described and our Kanthal alloys mentioned. As you know, we manufacture three types— Kanthal A-1, Kanthal A and Kanthal D— which under suitable atmosphere, supports, etc., give excellent life up to 2462 F for Kanthal A-1. The figure given in your article is 2300 F, which is much below the maximum limit.

We are sorry to see that our Kanthal alloys are not mentioned in a very favorable way. You are right in saying that Kanthal alloys may sag at the highest operating temperatures. Indeed, the excellent properties of these alloys in regard to heat resistance, high electric resistance, etc., are successfully utilized without any difficulties whatever caused by low creep stress at elevated temperatures.

Very truly yours,
Hans von Kantzow
Akliebolaget Kanthal
Hallstahammar, Sweden

We are sorry that Reader Kantzow considered our reference to Kanthal alloys as unfavorable. Actually the article referred to states that Kanthal alloys together with Smith No. 10 are used at the highest operating temperatures given for all the resistance alloys listed. In addition the author states that the heating element temperatures of Kanthal heated furnaces can be 2400 F, only 62 degrees lower than the temperature Mr. Kantzow cites. The 2300 F temperature mentioned in the article is the furnace temperature, not that of the resistor, a point which we felt was made clear in the article.—The Editors.



From this Point on . . .

Let's *make* a point *with* a point.

In the chart above—which shows how unit costs drop with increased production—note the point of intersection. From that point on powder metallurgy is the more economical means of parts manufacture.

And the reason is simple!

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Of course the curves here shown are highly simplified. They merely suggest a typical case.

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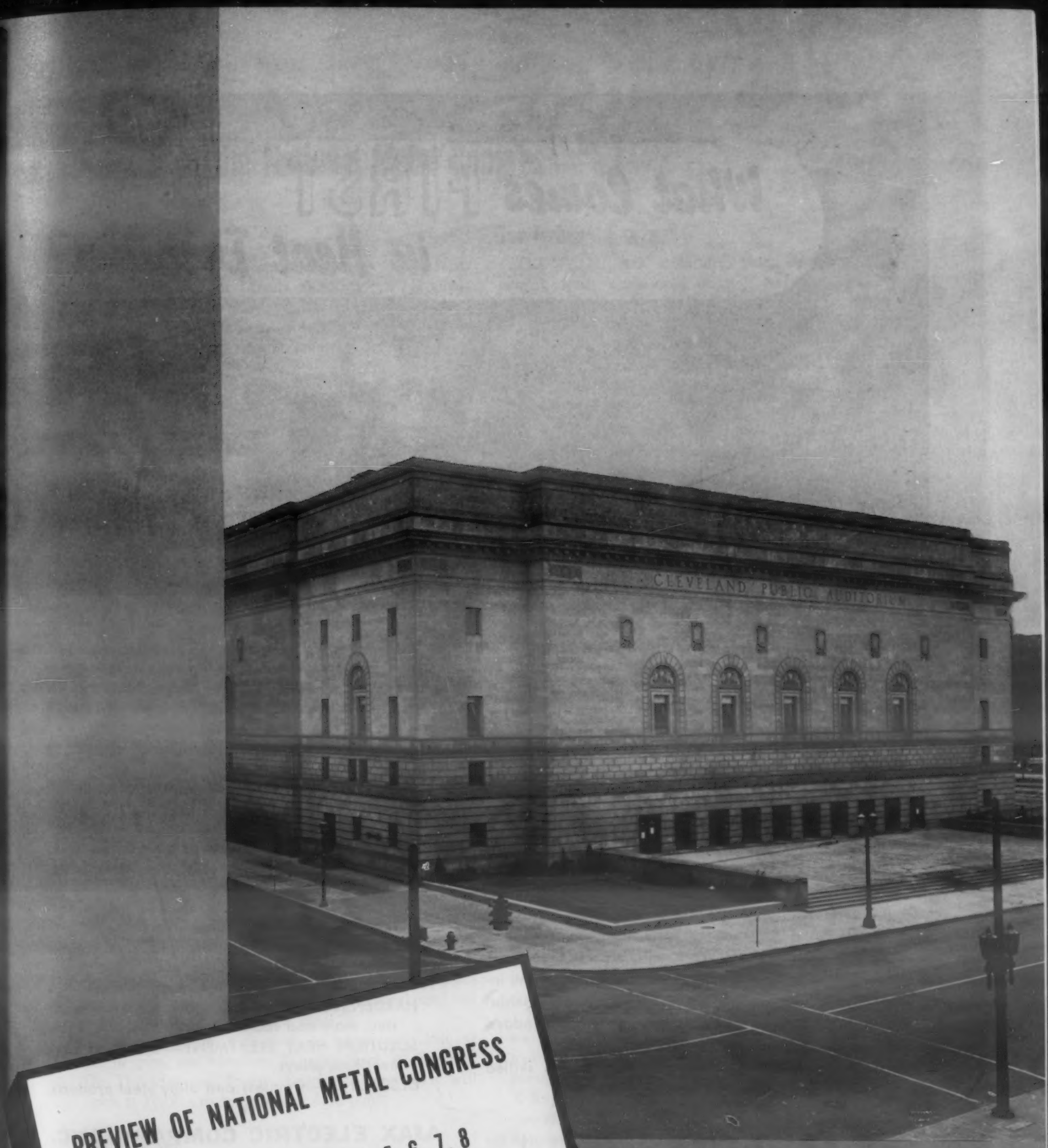

PREVIEW OF NATIONAL METAL CONGRESS

Cleveland, Ohio, Feb. 4, 5, 6, 7, 8

Introduction	Page 161
Officers	Page 165
A. S. M. Technical Program	Page 169
American Industrial Radium & X-Ray Society	Page 175
List of Exhibitors	Page 177

What Comes FIRST in Heat Treating?

Millions of dollars have been invested in AJAX HULTGREN Salt Bath Furnaces. Already there are over 2000 installations! Why? Because every vital plant is taking advantage of the "firsts" offered by AJAX. Here they are:

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BRAZING—ferrous and non-ferrous assemblies
HARDENING HIGH SPEED STEEL TOOLS—tungsten, moly and cobalt types
SOLUTION HEAT TREATMENT—aluminum and beryllium alloys
DESCALING—stainless and alloy steel products

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Preview of the National Metal Congress

Introduction

It has been the custom for some years for the American Society for Metals to sponsor a National Metal Congress each year annually in October. It includes a group of technical sessions and an exposition on a large scale of manufacturers of metals, equipment, supplies, etc.

Due to war conditions and the Government ban on conventions, the regular 1945 event was not held last October. Soon after the close of the war and the lifting of the restrictions on conventions, authorities of the A.S.M. seriously considered the advisability of holding a 1945 postponed Congress. The result of this was the announcement of the convening of such an event in February, 1946, in Cleveland.

The postponed Congress is designated as the 27th National Metal Congress and Exposition. It is to be held in Cleveland, February 4 to 8, 1946. The headquarters of the A.S.M. is the Hotel Statler with the Exposition located in the large Cleveland Public Auditorium. Sessions of the American Radium & X-Ray Society will be at the Hotel Hollenden.

Every indication points to a very large attendance —"in excess of 30,000 industrial visitors," according to W. H. Eisenman, managing director of the event and national secretary of the A.S.M.

It is understood that, while this February 1946 event is a postponed 1945 Congress, the regular annual 1946 National Metal Congress and Exposition will be held in the fall of 1946, probably in October.

The Exposition

Cleveland's large and celebrated Public Auditorium will house the 27th Annual Metal Show, February 4 to 8, postponed from last fall. More than 350 manufacturers of metals, equipment and processes will participate. Many developments of wartime production will be available for general industrial use and publicly shown for the first time.

The exposition will open at noon and close at 10:30 p.m. on Monday, Tuesday, and Wednesday. On Thursday and Friday, February 7 and 8, it will open at 10.00 a.m. and close at 6.00 p.m.

The Banquet

A feature of the annual dinner of the A.S.M. Thursday evening, February 7, in the grand ballroom of the Hotel Statler will be the presentation of four awards: The Henry Marion Howe Medal for the paper of highest merit published in *Transactions* during 1944; the Albert Sauveur Achievement Award; the A.S.M. Medal for the Advancement of Research; and the A.S.M. Gold Medal.

The Technical Programs

The A.S.M. has scheduled thirty-one technical papers, four educational courses and three round table evening sessions. Preliminary announcements indicate that the daily technical programs of the Congress will feature more than one hundred engineering experts presenting some seventy lectures and research papers.

Sessions have been arranged so that visitors who wish to spend only one or two days at Cleveland may select those days of special technical interest.

In the A.S.M. program the technical papers will be concentrated in the first three days of the Congress—Monday, Tuesday, and Wednesday, February 4, 5, and 6. The educational lectures will be presented on Thursday and Friday, February 7 and 8. In these some outstanding authorities will discuss magnesium, induction heating, corrosion of metals and the effect of surface stressing of metals on endurance in repeated loadings. Morning sessions will meet in the Hotel Statler, afternoon sessions at the Public Auditorium.

For the past four years some highly popular round table or panel-type discussions have been a feature of the Congress. Another series will be held this year each evening on Monday, Tuesday and Wednesday, February 4, 5, and 6 at the Public Auditorium.

Participating Societies

When the National Metal Congress has been held at the usual season and not postponed as in this case, several other societies have arranged sessions for the presentation of technical papers. These include the American Welding Society and the Metal Division of the American Institute of Mining Engineers. These organizations will not join the Congress in February —the A.W.S. held its convention last October, and the Iron and Steel Division and the Institute of Metals of the A.I.M.E. will meet in Chicago late in February.

So, for the February Metal Congress, only one other society will present a technical program in addition to that of the A.S.M. About thirteen papers will be presented by the American Industrial Radium and X-Ray Society, Inc. at the Hotel Hollenden, its headquarters. These are scheduled for Wednesday, Thursday and Friday, February 6, 7, and 8.

Campbell Memorial Lecture

The annual Edward de Mille Campbell Memorial lecture is always a feature of the Congress. The 1945 lecture will be delivered on Wednesday morning, February 6 by Dr. Maxwell Gensamer of Pennsylvania State College, State College, Pa. Dr. V. N. Krisobok will preside.

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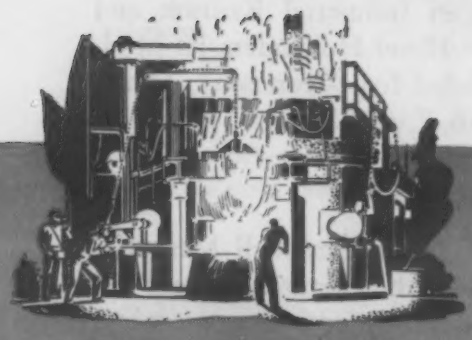

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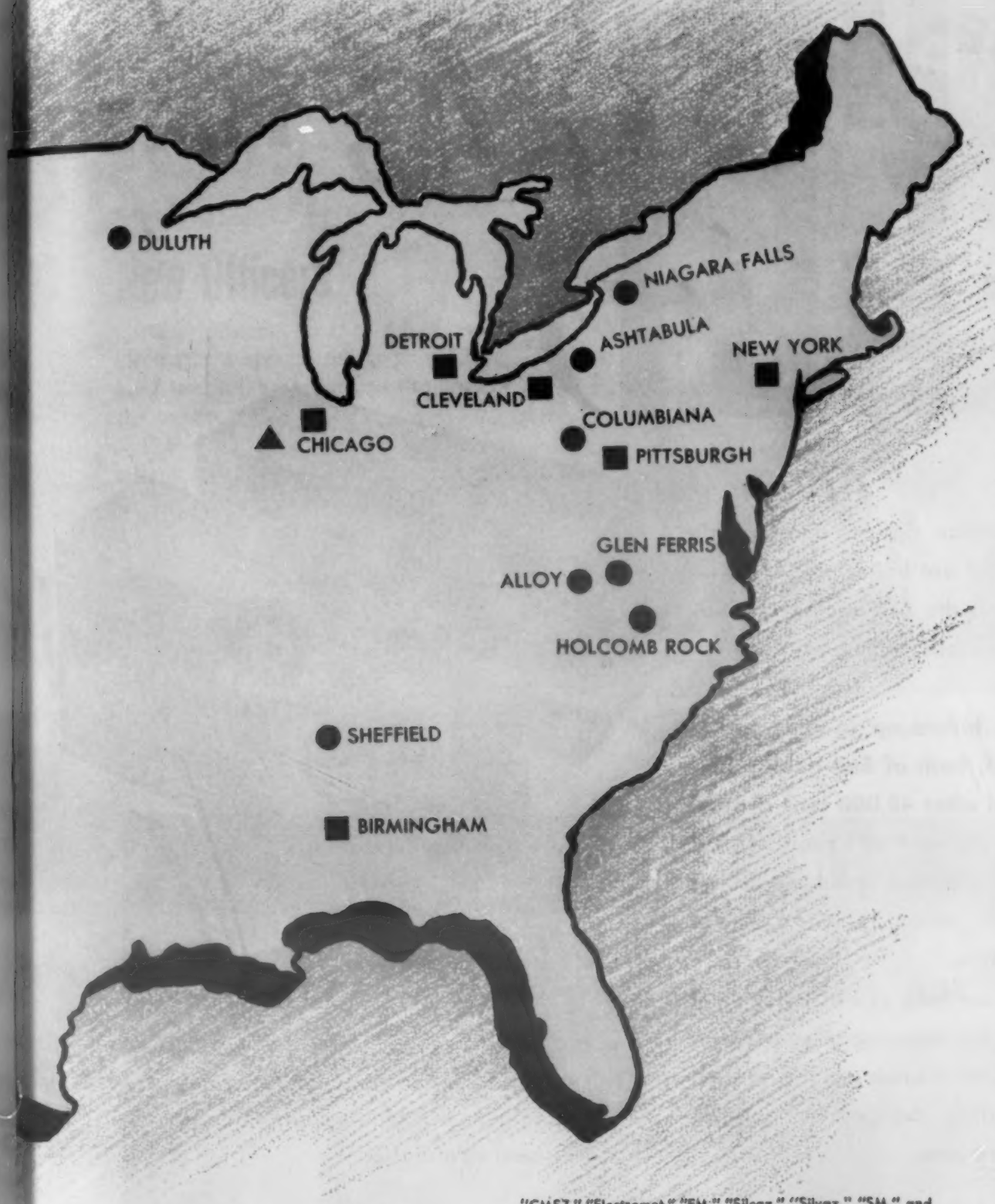

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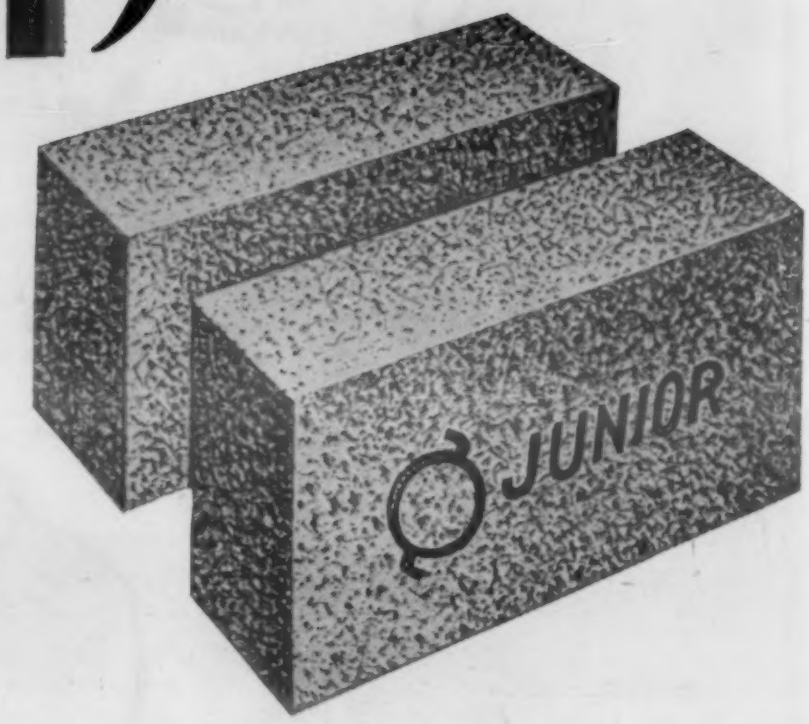

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New Officers

New officers of the A.S.M. were elected at a special meeting in Cleveland last fall, according to the laws of the society. They are:

President, Charles H. Herty, Jr., Assistant to the Vice President, Bethlehem Steel Co., Bethlehem, Pa.

Vice President, A. L. Boegehold, head of the Metallurgy department, Research Laboratories Div., General Motors Corp., Detroit, Mich.

Treasurer, H. K. Work, manager of research and development, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

Secretary, W. H. Eisenman.

Charles H. Herty, Jr., President, American Society for Metals.

A. L. Boegehold, Vice President, American Society for Metals.

H. K. Work, Treasurer, American Society for Metals.

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Technical Program

American Society for Metals

A rather unusual program of technical material has been arranged for the National Metal Congress. It will consist of a group of technical papers to be presented on the first three days of the week, February 4, 5, and 6, and a series of educational lectures on the last two days, February 7 and 8. The programs for the technical papers and the lectures, both sponsored by the A.S.M., are scheduled for presentation at the society's headquarters, the Statler Hotel, in the mornings and at the Public Auditorium in the afternoons.

The technical sessions comprise thirty-one papers by about fifty leading technical authorities. The educational lectures are on four timely topics and are five in number. The tentative programs for these two groups of meetings are as follows:

MONDAY MORNING, FEB. 4

"Drawability of Aluminum Alloys at Elevated Temperatures. Part I—Deep Drawing Cylindrical Cups," by D. M. Finch, Research Engineer; S. P. Wilson, Engineer, and Dr. J. E. Dorn, University of California, Berkeley, Calif.

"Deep Drawing Aluminum Alloys at Elevated Temperatures. Part II—Deep Drawing Boxes," by D. M. Finch, Research Engineer; S. P. Wilson, Engineer, and Dr. J. E. Dorn, University of California, Berkeley, Calif.

"New Aluminum Alloys Containing Small Amounts of Beryllium," by Dr. R. H. Harrington, General Electric Co., Schenectady, N. Y.

SIMULTANEOUS SESSION

"The Partition of Molybdenum in Hypo-Eutectoid Iron-Carbon-Molybdenum Alloys," by Fred E. Bowman, Climax Molybdenum Co., Detroit, Mich.

"The Effect of Variations in Composition and Heat Treatment on Some Properties of 4 to 6% Chromium Steel Containing Molybdenum and Titanium," by Geo. F. Comstock, Chief Metallurgist, Titanium Alloy Mfg. Co., Niagara Falls, N. Y.

"Iron-Manganese Alloys—the Properties of Cold-Worked and Heat Treated Alloys Containing 1 to 7% Manganese," by Dr. R. S. Dean, J. R. Long, Senior Metallurgist, T. R. Graham, Senior Metallurgist, and R. G. Feustel, Ass't Metallurgist, Bureau of Mines, Washington, D. C.

SIMULTANEOUS SESSION

"The Application of Ms Points to Case Depth Measurement," by Dr. E. S. Rowland and S. R. Lyle, Timken Roller Bearing Co., Canton, Ohio.

"A Mechanism of the Surface Decarburization of Steel," by W. A. Pennington, Chief Chem. & Metallurgist, Carrier Corp., Syracuse, N. Y.

"Graphite in Cold Rolled Subcritically Annealed Hypo-Eutectoid Steels," by M. A. Hughes and J. G. Cutton, Carnegie-Illinois Steel Corp., Youngstown, Ohio.

TUESDAY MORNING, FEB. 5

"High Forging Temperatures Revealed by Facets in Fracture Tests," by J. Robert Strohm, Chicago Dist. Mgr. Copperweld Steel Co., Chicago, Ill. and W. E. Jominy, Chief Metallurgist, Chrysler Corp., Detroit, Mich.

"Critical Points of SAE 4340 Steel as Determined by the Dilatometric Method," by D. Niconoff, Republic Steel Corp., Canton, Ohio.

"Gas Evolution from Cast Steel at Room Temperature," by H. H. Johnson, Metallurgist, L. H. Arner, Chief Chemist and Dr. H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland, Ohio.

SIMULTANEOUS SESSION

"The Effects of Combined Stresses and Low Temperatures on the Mechanical Properties of Some Non-Ferrous Metals," by Dr. D. J. McAdam, Jr., Metallurgist, G. W. Geil, Ass't Metallurgist, and Dr. R. W. Mebs, National Bureau of Standards, Washington, D. C.

"Temper Brittleness," by Capt. John H. Hollomon, Watertown Arsenal, Watertown, Mass.

"Fracture of Metals Under Combined Stresses," by Dr. D. J. McAdam, Jr., National Bureau of Standards, Washington, D. C.

SIMULTANEOUS SESSION

"Soft Soldering," by M. E. Fine and Prof. R. L. Dowdell, University of Minnesota, Minneapolis, Minn.

"The Cold Working and Heat Treatment of a 10-Karat Gold Alloy," by Vernon H. Patterson, Chief Metallurgist, and B. N. Iannone, Bausch & Lomb Optical Co., Rochester, N. Y.

"Tellurium in the Iron Foundry," by James O. Vadeboncoeur, Research Metallurgist, General Motors Corp., Pontiac, Mich.

TUESDAY AFTERNOON, FEB. 5

"Investigation of a Type of Failure of 18:8 Stabilized Stainless Steel," by W. C. Kahn, General Supervisor, New York Testing Laboratories, New York, N. Y., H. Oster, Ass't Director, and R. Wachtell, Metallurgist, Republic Aviation Corp., Farmingdale, L. I., N. Y.

"The Influence of Carbon Content Upon the Transformations in 3% Chromium Steel," by Dr. Taylor Lyman, Editor of Metals Handbook, A.S.M.—Cleveland, O. and Dr. A. R. Troiano, University of Notre Dame, Notre Dame, Ind.

"Effect of Nickel on Physical Properties and Thermal Characteristics of Some Cast Chromium-Molybdenum Steels," by N. A. Ziegler, Research Metallurgist, and W. L. Meinhart, Ass't Research Metallurgist, Crane Co., Chicago, Ill.

(Continued on page 173)

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 continued from page 169

SIMULTANEOUS SESSION

"Factors Affecting the Hardenability of Boron-Treated Steels," by R. A. Grange and T. M. Garvey, U. S. Steel Corp. Research Laboratories, Kearney, N. J.

"Quenching of Steel Balls and Rings," by Victor Paschkis, Research Associate, Columbia University, New York, N. Y.

"Mass Temperature Effects on Quenching 36% Cobalt Magnet Steel," by Benjamin Falk, Simonds Saw & Steel Co., Lockport, N. Y.

WEDNESDAY MORNING, FEB. 6

Edward de Mille Campbell Memorial Lecture, by Dr. M. Gensamer, Pennsylvania State College, State College, Penna.

WEDNESDAY AFTERNOON, FEB. 6

"Anti-Reflection Films for Metallographic Objectives," by James R. Benford, Bausch & Lomb Optical Co., Rochester, N. Y.

"Detection, Causes and Prevention of Injury in Ground Surfaces," by L. P. Tarasov, Norton Co., Worcester, Mass.

"The Practical Application of Statistical Methods in a Quality Control Program," by W. T. Rogers, Chief Statistician, National Tube Co., Lorain, Ohio.

SIMULTANEOUS SESSION

"Stress Comparisons by Correlation With High Frequency Magnetic and Eddy Current Losses," by P. E. Cavanagh, Chief Metallurgist, Allen B. DuMont Labs., Passaic, N. J.

"Metallurgical Characteristics of Induction-Hardened Steel," by James W. Poynter, Metallurgist, Army Air Forces, Wright Field, Dayton, Ohio.

"Induction Hardening and Austenitizing Characteristics of Several Medium Carbon Steels," by D. L. Martin, Research Metallurgist, General Eelctric Co., Schenectady, N. Y. and Prof. W. G. Van Note, North Carolina State College, Raleigh, N. C.

THURSDAY, FEB. 7—9:00 A. M.

Lecture 1 on Magnesium: Origin of Metal and Basic Properties, by Prof. L. M. Pidgeon, University of Toronto, Toronto, Canada.

Lecture 1 on Induction Heating: Principles and Theory of Induction Heating (Including Dielectric Induction Heating), by Dr. H. B. Osborn, Jr., Ohio Crankshaft Co., Cleveland, Ohio.

Lecture 1 on Surface Stressing: The Problem Defined, by Prof. H. F. Moore, University of Illinois, Urbana, Ill.

Lecture 1 on Corrosion: Basic Principles of Metallic Corrosion, by Dr. Carl W. Borgmann, University of Colorado, Boulder, Colo.

THURSDAY, FEB. 7—10:30 A. M.

Lecture 2 on Magnesium: Magnesium Structural Design, by J. C. Mathes, Development Engineer, Dow Chemical Co., Midland, Mich.

Lecture 2 on Induction Heating: Induction Heating Circuits and Frequency Generation, by Dr. P. H. Brace, Westinghouse Electric Corp., E. Pittsburgh, Pa.

Lecture 2 on Surface Stressing: Measurement of Stresses at Surface, by Dr. W. M. Murray, Society for Experimental Stress Analysis, Cambridge, Mass.

Lecture 2 on Corrosion: Effect of Composition and Environment on Corrosion of Iron and Steel, by C. P. Larrabee, Carnegie-Illinois Steel Corp., Vandergrift, Pa.

THURSDAY, FEB. 7—4:30 P. M.

Lecture 3 on Magnesium: Castings, by Dr. N. E. Woldman, Bendix Aviation Corp., Teterboro, N. J.

Lecture 3 on Induction Heating: Practical Application of the Motor-Generator Type of Induction Heating (Frequency up to 10,000 Cycles), by W. G. Johnson, Caterpillar Tractor Co., Peoria, Ill.

Lecture 3 on Surface Stressing: Methods of Applying and Tests Used Including Carburizing and Nitriding, by J. O. Almen, Head of Mechanical Dept. Research Laboratories, General Motors Corp., Detroit, Mich.

Lecture 3 on Corrosion: Corrosion Resistance of Stainless Steels and High Nickel Alloys, by W. O. Binder, Union Carbide & Carbon Research Laboratories, Niagara Falls, N. Y.

FRIDAY, FEB. 8—9:00 A. M.

Lecture 4 on Magnesium: A Survey of Wrought Magnesium Alloy Fabrication, by J. V. Winkler, Dow Chemical Co., Los Angeles, Calif.

Lecture 4 on Induction Heating: Practical Applications of High Frequency Induction Heating (100,000 Cycles and Up), by J. W. Cable, Induction Heating Corp., New York, N. Y.

Lecture 4 on Surface Stressing: Stressing Axles and Other Railroad Equipment by Cold Rolling, by O. J. Horger, Chief Engineer Railway Division, Timken Roller Bearing Co., Canton, Ohio.

Lecture 4 on Corrosion: Corrosion of Light Metals (Aluminum and Magnesium), by Dr. E. H. Dix, Jr., Aluminum Co. of America, New Kensington, Pa.

FRIDAY, FEB. 8—10:30 A. M.

Lecture 5 on Magnesium: Corrosion, by W. S. Loose, Dow Chemical Co., Midland, Mich.

Lecture 5 on Induction Heating: Comparison of Induction Heating to Other Methods of Heat Treating, by T. E. Eagan, Chief Metallurgist, Cooper-Bessemer Corp., Grove City, Pa.

Lecture 5 on Surface Stressing: Progressive Stress Damage, by Peter R. Kosting, Watertown Arsenal, Watertown, Mass.

Lecture 5 on Corrosion: Corrosion of Copper and Brass, by H. L. Burghoff, Research Metallurgist, Chase Brass & Copper Co., Waterbury, Conn.

The Educational Lectures

Four Lecture Courses On:

- Magnesium
- Induction Heating (Without Melting)
- Effect of Surface Stressing of Metals on Endurance in Repeated Loadings
- Corrosion of Metals

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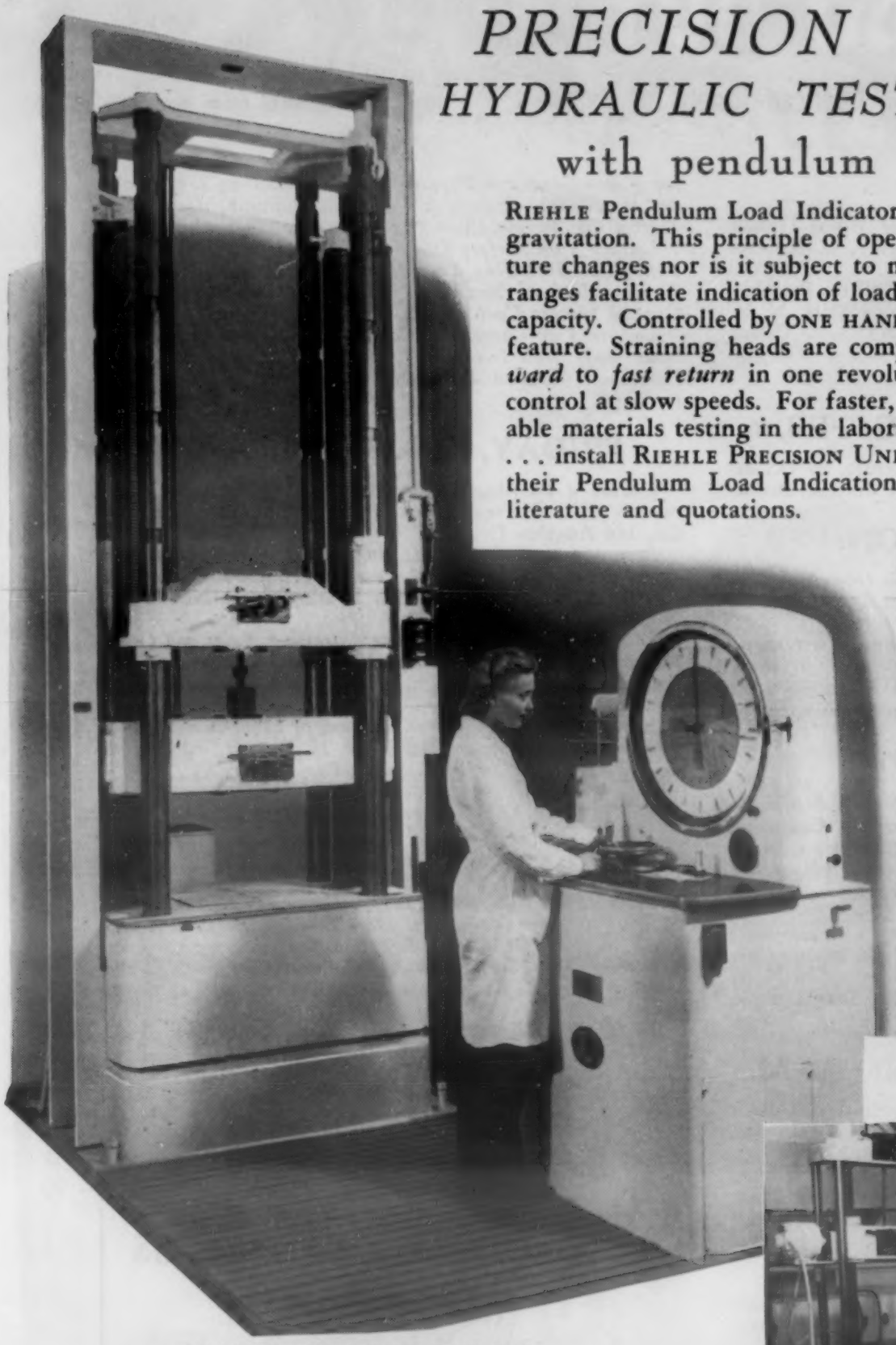
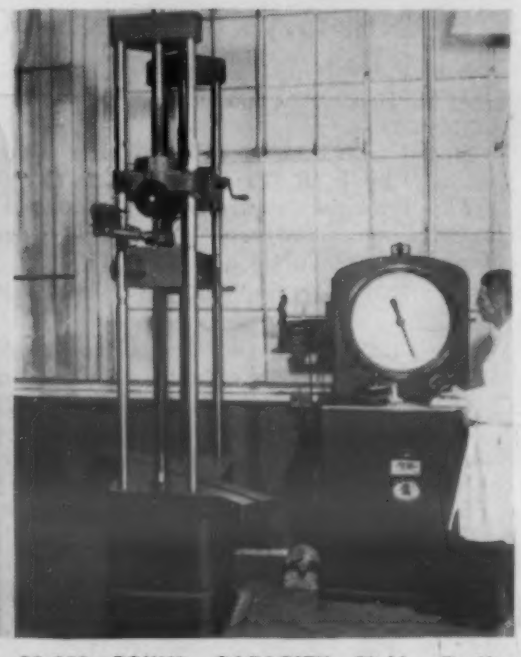


200,000 POUND CAPACITY *Riehle Testing Machine with tension test on a steel part in progress. Installation in Production Development Lab. of North American Aviation, Inc., California Div.*



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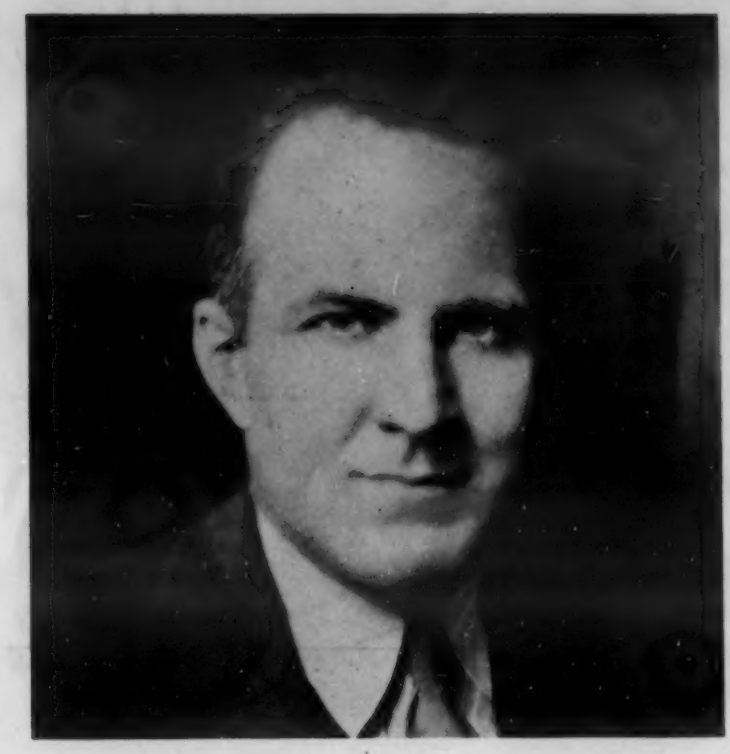

Kent R. Van Horn, President, American Industrial Radium & X-Ray Society.

American Industrial Radium & X-Ray Society Convention

February 6, 7 and 8

Program Tentatively Scheduled as of December 27, 1945.

Wednesday, February 6
10:00 A.M.

Short business meeting of the Society.

10:30 A.M.

Lester Lecture—Mr. O. R. Carpenter
The Babcock & Wilcox Co.
Barberton Works
Barberton, Ohio
"Advances in Steel Weldments in the Past Few Years"

2:00 P.M.

Technical Session
(Three papers on forms of non-destructive testing other than radiography.)

Thursday, February 7
10:00 A.M.

Technical Session
"The Radiography of Captured Enemy Equipment by the U. S. Navy," by Lt. Donald T. O'Connor
"Device and Method of Quantitive Analysis by X-Ray Diffraction," by Stanley A. Brosky
"The Influence of Inherent Filtration of the X-Ray Tube in Industrial Radiography and Fluoroscopy," by E. Dale Trout

2:00 P.M.

Technical Session
"X-Ray in the Inspection of Ammunition," by Captain Roy E. Thorpe
"Gamma Radiography of Rail Welds in Moffat Tunnel" (Speaker to be announced later)
"The Correlation Between Zyglo and X-Ray Inspection of Castings," by Wm. F. Alderson

Friday, February 8

A full day symposium sponsored by Committee E-7 of the American Society for Testing Materials, the theme of which will be "Ultra High Voltage and High Speed Radiography," comprising subjects of current interest discussed by some of the world's most outstanding speakers.

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List of Exhibitors

Leading manufacturers of metals, equipment and processes numbering at least 350 are scheduled to participate in "industry's largest metal show" in Cleveland's Public Auditorium, February 4 to 8, 1946. Some 30,000 visitors are expected to attend the exposition, according to W. H. Eisenman, managing director of the event and national secretary of the Society.

A tentative list of the exhibitors follows:

	Booth
Ace Abrasive Laboratories	G 605
Agaloy Tubing Co.	A 749
Aimes Engineering Co.	D 744
Air Hydraulics	K 631
Air Reduction Sales Co.	D 621
Akron Bronze & Aluminum Co.	F 110
Allegheny Ludlum Steel Corp.	B 410
Allen Mfg. Co.	B 142
Allis-Chalmers Co.	C 603
Allison Co.	D 315
Alloy Casting Co.	C 113
Alox Corp.	P 521
Aluminum Co. of America	C 122
Aluminum Industries, Inc.	A 334
Alvey-Ferguson Co.	G 608
American Brake Shoe Co.	B 122
American Brass Co.	D 320
American Chain & Cable Co., Inc.	D 311 & D 314
American Chain Ladder Co.	C 736
American Cynamid & Chemical Corp.	P 523
American Cystoscope Makers, Inc.	H 610
American Foundrymen's Assoc.	E 109
American Gas Association	F 617
American Gas Furnace Co.	C 110
American Machine & Gage Co.	H 633
American Machinist	H 604
American Machine & Metals, Inc.	E 604
American Measuring Instruments Corp.	F 130
American Photocopy Equipment Co.	A 321
American Welding & Mfg. Co.	A 739
Ampco Metal, Inc.	D 611
Anderson Brothers Mfg. Co.	D 310
Anderson Oil Co., F. E.	H 621
Annis Co., R. B.	I 627
Ansco Div.-General Aniline & Film Corp.	E 137
Aro Equipment Corp.	C 633
Adkins & Co., E. C.	A 760
Atlas Metal Stamping Co.	B 741
Austenal Laboratories, Inc.	G 604
Automatic Temperature Control Co., Inc.	B 310
Automatic Transportation Co.	A 405
Automotive & Aviation Industries	A 131
Avery Engineering Co.	C 630

	Booth
Baker-Raulang Co.	D 604
Barco Machine Products Co.	C 709
Barrett-Cravens Co.	C 624
Bath Co., Cyril	B 736
Bausch & Lomb Optical Co.	B 141
Bell & Gossett Co.	G 617
Bellis Heat Treating Co.	A 306
Bergen Precision Castings Co.	B 118
Beryllium Corp. of Penn., The	B 709
Black Drill Co.	E 114
Black Mfg. Co.	C 754
Braeburn Alloy Steel Corp.	D 728
Bramson Publishing Co.	B 725
Brickseal Refractory Co.	D 750
Bridgeport Brass Co.	A 315
Briggs Manufacturing Co.	I 621
Brown Corp., W. R.	C 736
Bruning Co., Inc., Charles	C 741
Brush Beryllium Co.	H 614
Brush Development Co.	E 617
Bryant Heater Co.	F 610
Budd Induction Heating, Inc.	A 601
Buehler Ltd.	B 135
By-Products Steel Corp.	B 110

	Booth
Cambridge Wire Cloth Co.	A 745
Campbell Division, Andrew C.	D 311
Canadian Radium & Uranium Corp.	J 611
Carboloy Co., Inc.	C 340
Carborundum Co.	E 628
Carpenter Steel Co.	D 102
Central Scientific Co.	A 744
Chace Co., W. M.	A 310
Chayes Dental Instrument Co.	K 601
Chemical Rubber Co.	C 330
Chilton Publications	C 150
Chicago Flexible Shaft Co.	A 341
Cities Service Oil Co.	D 709
Cleveland Crane & Engineering Co.	J 604
Cleveland Metal Processing Co.	I 610
Cleveland Pneumatic Tool Co.	D 605
Cleveland Tapping Machine Co.	C 315
Clinton Machine Co.	A 143
Commerce Pattern Foundry & Machine Co.	P 519
Compar-Instrument Co.	A 704
Conover-Mast Corp.	D 601
Cramer Co., Inc., R. W.	B 335
Cut-Off Clinic	A 605 & B 603

	Booth
Deepfreeze Div.-Motor Products Corp.	D 714
Delaware Tool Steel Corp.	A 325
Delta Manufacturing Co.	A 605
Denison Engineering Co.	P 500
Despatch Oven Co.	A 320
Detrex Corp.	D 325
Detroit Stamping Co.	D 724
Detroit Surfacing Machine Co.	A 627
DeWalt Products Corp.	D 330
Die Casting	P 510
Dietert Co., Harry W.	B 414
Dilley Manufacturing Co.	I 622
Dillon & Co., Inc., W. C.	I 611
Divine Brothers Co.	C 734
Doall Cleveland Co.	B 340
Doall Co.	B 340
Dow Chemical Co.	B 321
Driver-Harris Co.	A 720
DuMont Laboratories, Inc., Allen B.	A 735
DuPont de Nemours & Co., E. I.	C 130
Duraloy Co., The	P 513

	Booth
Eastern Stainless Steel Corp.	D 130
East Ohio Gas Co.	F 617
East Shore Machine Prod. Co.	A 111
Eastman Kodak Co.	B 409
Elox Corporation	F 124
El Taller Mecanico Moderno	I 632
Elastic Stop Nut Corp. of America	A 640
Electro-Alloys Div.-American Brake Shoe Co.	B 122
Electro Metallurgical Co.	G 621
Electro Refractories & Alloys Corp.	P 523
Elgin National Watch Co.	D 331
Elwell-Parker Electric Co.	B 403
Eutectic Welding Alloys Co.	C 310
Executone Systems	A 630

	Booth
Fansteel Metallurgical Corp.	P 501
Farmers Engineering & Mfg. Co.	I 634
Fawick Airflex Co., Inc.	A 726
Faxfilm Co.	B 723
Federal Products Corp.	P 520
Federal Telephone & Radio Corp.	B 740
Fiberglas Corp.	A 730
Finnell System Inc.	A 711
Firth-Sterling Steel Co.	B 146
Flow	P 510
Forrest City Foundries Co.	G 613
Fostoria Pressed Steel Corp.	C 751
Foundry	P 504
Frontier Bronze Corp.	E 110
Fulton Foundry & Machine Co., Inc.	D 624

	Booth
Gamma Instrument Co., Inc.	H 623
Gardner Publications, Inc.	I 632
Gas Appliance Service, Inc.	A 337
Gas Machinery Co.	F 611
General Alloys Co.	C 146
General Analine & Film Corp.	E 137
General Tool & Die Co., Inc.	C 706
Globe Stamping Div.	I 623
Gray-Mills Co.	C 601
Great Lakes Steel Corp.	C 730
Gulf Oil Corp.	A 410

	Booth
H & H Research Co.	P 522
Hager & Son, E. F.	A 748
Harper Co. H. M.	A 727
Harris Foundry & Machine Co.	C 702
Haynes Stellite Co.	G 621
Heil Engineering Co.	A 624
Hercules Electric & Mfg. Co.	G 611
Heubner Publications	A 629
Hevi Duty Electric Co.	C 141
Hitchcock Publishing Co.	J 601
Hines Co.	A 704
Holden Co., A. F.	B 147
Hoskins Mfg. Co.	A 722
Houghton & Co., E. F.	D 337
Hupp Motor Car Corp.	I 623
Hydraulic Machinery, Inc.	B 720

	Booth
Ideal Commutator Dresser Co.	C 715
Illinois Testing Laboratories, Inc.	D 138
Illinois Tool Works	B 324
Independent Pneumatic Tool Co.	G 603
Induction Heating Corp.	D 340
Industrial Bulletin	D 700
Industrial Heating	D 745
Industrial Gas Center	F 617
Industrial Press	E 133
Industrial Publishing Co., The	P 510
Industrial Steels, Inc.	D 130

Industrial Tape Corp. ....B 746
Industry & Welding ....P 510
Infra-Red Engineers & Designers ....A 123
Instrument Specialties Co. ....D 335
Intercontinental Engineers, Inc. ....C 332
International Nickel Co. ....B 102
Iron Age, The ....C 150

	Booth
Jack & Heintz, Inc.	B 320
Janney Cylinder Co.	H 605
Jones Co., C. Walker	I 624

	Booth
Kelley Co., J. W.	C 137
Kennametal, Inc.	B 130
Kerr Dental Mfg. Co.	I 629
Kett Tool Co.	D 737
King, Andrew	D 118
Kinzie Stampers Div.	H 633
Kolene Corp.	C 114
Krouse Testing Machine Co.	A 734
Kux Machine Co.	A 311

	Booth
Lakeside Steel Improvement Co.	E 122
Lectroetch Co.	L 102
Lempco Products, Inc.	C 620
Lepel High Frequency Laboratories, Inc.	K 615
Lester-Phoenix, Inc.	A 330
Lewis-Shephard Products, Inc.	D 617
Lieser, George H.	A 704
Light Metal Age	D 712
Lincoln Engineering Co.	A 740
Lindberg Engineering Co.	D 146
Linde Air Products Co.	G 621
Lion Mechanical Works	I 625
Lithaloys Corp.	A 714
Lithium Co.	E 117
Lord Mfg. Co.	C 760
Lukens Steel Co.	B 110
Lukenweld, Inc.	B 110

	Booth
Machinery	E 133
Machine Tool Blue Book	J 601
Magnaflux Corp.	D 113
Magnetic Analysis Corp.	B 121
Malleable Founders' Society	H 607
Mallory & Co., Inc., P. R.	F 601
Manhattan Rubber Mfg.	A 605
Manufacturers Screw Products	D 741
Martindale Electric Co.	A 715
MATERIALS & METHODS	B 600
McGraw-Hill Publ. Co.	H 604
Melville Shoe Corp.	K 621
Metal Finishing	K 637
Metal Finishing Service	C 747
Metal Hydrides, Inc.	C 629
Metal Industries Catalog	B 600
Metallizing Co. of America	I 619
METALS & ALLOYS	B 600
Michiana Products Corp.	B 131
Midvale Co.	E 611
Milne & Co., A.	D 710
Mine Safety Appliances Co.	B 111
Modern Machine Shop	I 632
Modern Metals	F 120
Molybdenum Corp. of America	C 133
Monarch Steel Co.	P 526
Monroe Tool & Mfg. Co.	A 331
Morse Twist Drill & Machine Co.	D 736
Motch & Merryweather Machinery Corp.	E 621
Moto-True Company	K 620
Motor Products Co.	D 714
Mueller Co.	K 623

	Booth
National Bronze & Aluminum Foundry Co.	B 751
National Carbon Co.	G 621
National Diamond Hone & Wheel Co.	C 712
National Engineering Co.	B 115
National Industrial Pub. Co.	D 745
National Lead Co.	G 609
Nelson Specialty Welding Equipment Corp.	P 502
New-Field Co.	D 737
New Jersey Zinc Co.	B 730
Nichols-Morris Corp.	C 634
North American Mfg. Co.	C 320
North American Philips Co.	A 415
Norton Company	D 603

	Booth
Office Devices Co.	H 633
Oakite Products, Inc.	E 134
Oficina Mechanica Moderna	I 632
Ohio Carbon Co.	A 634
Ohio Crankshaft Co.	A 324
Ohio Overall Cleaning Co.	H 601
Ohio Seamless Tube Co.	K 610
Ohio Steel Foundry Co.	D 134
Olsen Testing Machine Co., Tinius	C 625
Osborn Mfg. Co.	B 331
Owens-Corning Fiberglas Corp.	A 730

	Booth
Page Steel & Wire Div.	D 314
Parker Appliance Co.	E 601
Parker-Kalon Corp.	A 703
Peerless Gear & Machine Co.	D 708
Penton Publishing Co.	P 504
Peters-Dalton, Inc.	B 611
Phillips Mfg. Co.	A 723
Physicists Research Co.	H 625
Pines Engineering Co.	A 700
Pioneer Alloy Products Co.	K 639
Pond Engineering Co.	A 625
Porter-Cable Machine Co.	L 103
Powermatic Ventilator Co.	E 610
Precise Products Co.	A 309
Precision Scientific Co.	I 605
Production Devices, Inc.	A 638
Production Engineering & Management	B 725
Products Finishing	I 632
Pyrometer Instrument Co.	P 517

	Booth
Radio Corp of America	C 740
Radium Chemical Co., Inc.	B 708
Ransburg Co., Harper J.	E 140
Ransohoff, Inc., N.	D 628
Raybestos-Manhattan, Inc.	A 605
Raytheon Mfg. Co.	A 404
Ready-Powder Co.	D 746
Reeves Pulley Co.	P 515
Reinhold Publ. Corp.	B 600
Republic Drill & Tool Co.	H 611
Revere Copper & Brass, Inc.	B 306
Reynolds Metals Co.	C 621
Rhode Island Tool Co.	A 738
Riehle Testing Machines Div.	E 604
Roebling's Sons Co., John A.	D 720
Rogers & Co., G. S.	A 707
Rolock, Inc.	B 739
Royal Oak Tool & Machine Co.	A 622
Rustless Iron & Steel Corp.	C 102
Ryerson & Son, Inc., Jos. T.	B 134

"S"	Booth
Corrugated Quench Gap Co.	K 609
Safety Clothing & Equipment Co.	G 611
Salkover Metal Processing Co.	I 610
Sapphire Products Div.	D 331
Scherr Co., Inc., Geo.	E 130
Schrader's Son, A.	I 628
Sciaky Brothers	B 605
Scientific Electric Div.	K 609
Sectional Brush Co.	
Selas Corp. of America	D 122
Sentry Co.	A 316
Sheffer Collet Co.	C 749
Sheldon & Co., E. H.	K 616
Shell Oil Co., Inc.	B 714
Sherman & Co.	B 315
Size Control Co.	H 633
Simonds Saw & Steel Co.	B 731
Simplex Engineering Co.	C 714
Snap-On Tools Corp.	A 743
Snyder, Almon O.	C 736 & D 737
Socony Vacuum Oil Co., Inc.	C 619
Solventol Chemical Products, Inc.	D 306
Sonntag Scientific Corp.	H 633
South Bend Lathe Works	B 704
Sparkler Mfg. Co.	A 721
Spencer Turbine Co.	G 610
Sperry Products, Inc.	G 601
Standard Oil Co. (Ohio)	B 609
Standard Steel Spring Co.	D 110
Steel	P 504
Sterling Alloys, Inc.	A 402
Stevens Grease & Oil Co.	C 622
Stone Co., Herman	C 750
Stone Machinery Co.	B 603
Stoody Co.	B 337
Stuart Oil Co. Ltd., D. A.	C 324
Sun Oil Co.	E 605
Superior Electric Co.	C 708
Superior Flux Co.	A 340
Sutton Engineering Co.	F 605
Sutton Publishing Co.	K 633

	Booth
Tabor Mfg. Co.	A 605
Tacoma Chamber of Commerce	F 604
Tal's Prestal Bender, Inc.	C 705
Tate-Jones & Co., Inc.	I 616
Tatra Tool Co.	A 626
Tempil Corp.	C 117
Tennant Co., G. H.	P 512
Texas Co.	H 617
Thermogen Corp.	A 633
Thom McAn Safety Shoe Div.	K 621
Tide Water Associated Oil Co.	D 324
Timken Roller Bearing Co.	P 518
Tinnerman Products, Inc.	I 617
Titanium Alloy Mfg. Co.	P 516
Tocco Div.	A 324
Torit Mfg. Co.	A 623
Torrington Mfg. Co.	B 606
Towmotor Corp.	E 631
Trends, Inc.	C 350
Trent Co., Harold E.	B 407
Trent Tube Mfg. Co.	B 750
Trifari, Krussman & Fishel, Inc.	K 627
Triplex Machine Tool Corp.	B 400

	Booth
Udylite Corp.	C 720
Ultra-Lap Machine Co.	B 735
Union Carbide & Carbon Corp.	G 621
United Chromium, Inc.	A 411
U. S. Hoffman Machinery Corp.	H 629
United Welding Co.	K 643
Upton Electric Furnace Div.	P 519

	Booth
Valvoline Oil Co.	A 621
Vanadium Alloys Steel Co.	A 401
Vanadium Corp. of America	B 314
Vapor Blast Mfg.	A 704
Vulcan Corp.	P 527

	Booth
Wall-Colmonoy Corp.	C 746
Walsh Press & Die Co.	H 633
Washington Steel Corp.	A 133
Webster Products Co.	A 753
Welding Engineering Publishing Co.	C 306
Weldon Roberts Rubber Co.	C 736
Wellman Bronze & Aluminum Co.	K 611
Wellman Co., S. K.	D 150
Wells Mfg. Corp.	A 731
Western Metals	F 140
Whistler & Sons, Inc., S. B.	B 705
Wickman Corp.	A 141
Wilson Mechanical Instrument Co.	C 142
Wood Products Corp., J. R.	B 747
Wright-Hibbard Industrial Electric Truck Co.	J 605

	Booth
Yale & Towne Mfg. Co.	A 414

	Booth
Zagar Tool, Inc.	A 708

MATERIALS & METHODS **Engineering File Facts**

NUMBER 103
January, 1946

METHODS: Induction Heating

INDUCTION AND DIELECTRIC HEATING FORMULAS

GENERAL R.F. HEATING FORMULAS

Load Thermal Power Requirement

$P_{kw} = 2.93 \times 10^{-4}\ MC\Delta T$ (kilowatts)

P = load thermal power requirement
M = lb./hr. of material to be heated
C = specific heat of substance
ΔT = temperature rise in degrees F.

Alternating Current Resistance of a Conductor

$R = 0.303 \sqrt{f}\, dR_{dc}$ (ohms)

R = a.c. resistance of conductor
f = frequency in cy./sec.
d = diam. of conductor in.
R_{dc} = d.c. resistance of a solid conductor of equal diam.

Capacitive Reactance

$X = \frac{1}{wC}$ (ohms)

X = capacitive reactance (ohms)
$w = 2\pi f$.
C = capacity (farads)
f = frequency (cy./sec.)

Radiation and Convection Loss from Surface (Thermal Losses)

$W_r = 37e\left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{T_2}{1000}\right)^4\right]$ watts/sq.in.

$W_c = 4.66 \times 10^{-4} (\Delta t)^{1.33}$ watts/sq.in.
T = 5/9 F+255.4 degrees Kelvin
F = degrees Fahrenheit
Δt = temperature rise in degrees F
e = relative emissivity = 1 for black body radiation

Inductive Reactance

$X = 2\pi fL$ ohms.

X = inductive reactance (ohms)
f = frequency cy./sec.
L = inductance in henries

INDUCTION HEATING FORMULAS

Power Input Into a Non-Magnetic Cylinder

$*P_v = \frac{16.3 H_o^2}{d} \sqrt{fp} \times 10^{-7}$ (watts/cu.in.)

P_v = power density in watts/cu.in.
H_o = peak magnetizing force (oersteds)
p = resistivity of work in micro-ohms-cms.
d = outside diam. of cyl. in inches
f = frequency in cy./sec.

Power Input Into a Non-Magnetic Slab

$*P_v = \frac{8.15 H_o^2}{t} \sqrt{fp} \times 10^{-7}$ (watts/cu.in.)

P_v = power density in watts/cu.in.)
H_o = peak magnetizing for (oersteds)
p = resistivity of work in micro-ohms-cms.
t = thickness of slab in inches
f = frequency in cy./sec.

Power Input Into a Magnetic Cylinder

$*P_v = \frac{2.75 \times 10^{-4}}{d} \sqrt{pf}\, H_o^{3/2}$ (watts/cu.in.)

P_v = power density in watts/cu.in.
d = diam. of cylinder in inches
p = resistivity of material in micro-ohms-cms.
f = frequency in cy./sec.
H_o = peak magnetizing force (oersteds)

Power Input Into a Magnetic Slab

$*P_v = \frac{1.37 \times 10^{-4}}{t} \sqrt{pf}\, H_o^{3/2}$ (watts/cu.in.)

P_v = power density in watts/cu.in.)
p = resistivity of material in micro-ohms-cms.
f = frequency in cy./sec.
H_o = peak magnetizing force (oersteds)
t = thickness of slab inches

Depth of Current Penetration in a Non-Magnetic Conductor

$\delta = 1.98 \sqrt{\frac{p}{f}}$ (Inches)

δ = depth of current penetration (inches)
p = resistivity of material (micro-ohm-cm)
f = frequency in cy./sec.

Depth of Current Penetration in a Magnetic Conductor

$\delta = 1.98 \sqrt{\frac{p}{\mu f}}$ (inches)

δ = depth of current penetration (inches)
p = resistivity of material (micro-ohm-cm)
f = frequency in cy./sec.
μ = magetic permeability
$\mu = 1.8\ B/Ho$
B = magnetic flux density (gauss) (usually assumed as 16,000)
H_o = peak magnetizing force at surface of material (oersteds)

Coil Voltage and Current

$E = 2.86\ H_o NAf K_2 \times 10^{-7}$ volts (rms)

$I = 1.43\ H_o \frac{1}{N}$ amperes (rms)

E = coil voltage in volts (rms)
I = coil current in amps. (rms)
H_o = peak magnetizing force (oersteds)
N = number of turns in coil
A = cross-section
l = length of coil in inches
f = frequency in cy./sec.
K_2 = coil voltage factor

Coil Inductance

$L = \frac{r^2 n^2}{9r\ 10l}$ microhenries

r = mean radius of coil
n = number of turns
l = length

** Formula applicable only if depth of penetration (δ) is less than 1/2 thickness (t) of slab or $\frac{1}{3}$ diameter of cylinder (d)*

Compiled by the Industrial Electronics Div., Westinghouse Electric Corp. Baltimore, Md.

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MATERIALS & METHODS Engineering File Facts

NUMBER 104
January, 1946

MATERIALS: Spring Materials

Spring Materials

Moduli of Elasticity and Allowable Stresses

Spring Material	Modulus of Elasticity		Allowable Stresses, p.s.i., for Compression Springs		
	E = Tension	G = Torsion	Light Service	Average Service	Severe Service
Hard-Drawn Steel, SAE 1350 & 1360	E = 29,000,000	G = 11,400,000	65,000	55,000	Not used
Music Wire, SAE 1085 & 1090	E = 30,000,000	(h) G = 12,000,000	100,000	85,000	70,000
Oil-Tempered, SAE X1065 (MB)	E = 29,000,000	G = 11,200,000	80,000	65,000	55,000
Annealed High-Carbon, SAE 1085 (HB)	E = 29,000,000	G = 11,500,000	82,000	70,000	57,000
Chromium-Vanadium, SAE 6150	E = 30,000,000	G = 11,200,000	85,000	75,000	60,000
Silicon-Manganese, SAE 9260	E = 29,000,000	G = 10,750,000	82,000	70,000	57,000
Silicon-Chromium	E = 30,000,000	G = 11,500,000	90,000	80,000	60,000
Flat C.R. Strip, SAE 1070	E = 30,000,000	G = 11,500,000	75,000	65,000	55,000
Clock Spring Strip, SAE 1095	E = 30,000,000	G = 11,500,000	80,000	70,000	60,000
Corrosion Resistant Materials					
Stainless 18:8, SAE 30915 & 30905	E = 26,500,000	G = 10,000,000	70,000	60,000	50,000
Stainless, Chromium, SAE 51335 & X51210	E = 28,500,000	G = 10,500,000	67,000	57,000	45,000
Inconel	E = 26,000,000	G = 10,500,000	65,000	55,000	40,000
Monel	E = 26,000,000	G = 9,500,000	55,000	45,000	35,000
K-Monel, Age Hardened	E = 26,000,000	G = 9,500,000	65,000	55,000	40,000
Z-Nickel, Age Hardened	E = 30,000,000	G = 11,000,000	65,000	55,000	40,000
Phosphor Bronze, SAE 81 & 77	E = 14,500,000	G = 6,000,000	50,000	40,000	30,000
Beryllium-Copper, ASTM B-120-41	E = 17,900,000	(g) G = 7,250,000	60,000	50,000	40,000
Manganese 720	E = 21,000,000	G = 7,100,000	60,000	50,000	40,000
Brass, SAE 80	E = 14,500,000	G = 5,000,000	40,000	30,000	Not used

E — Used for springs subjected to tensile stresses due to bending, such as torsion, flat, cantilever, clock and power springs.
G — Used for springs subjected to torsional stresses, such as compression and extension springs and rods used in torsion.

NOTE: The allowable stresses may be altered as follows:

(a) For wire diameters under 0.020 in., increased 20%; over 0.020 in. to 0.057 in. increased 10%.
(b) For compression springs that are preset and shotpeened, increased 10 to 15%.
(c) For torsion, flat, cantilever, clock and power springs, increased 50 to 75%.
(d) For extension springs, reduced 10 to 20%.
(e) For suddenly applied loads, reduced 50%. (Also for elevated temperatures.)
(f) The values shown include Wahl curvature correction factor.
(g) Will increase 1,000,000 with prolonged heat treatment.
(h) 11,750,000 for sizes over 0.100 in. diam.

Prepared by H. Carlson, Chief Engineer, Lee Spring Co., Inc.

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TA-1344

MATERIALS & METHODS Engineering File Facts

NUMBER 105
January, 1946

MATERIALS: Lead

Lead (Specifications and Properties)

Lead from the smelters and refiners is supplied as pigs, ingots, sheets, and in a variety of special forms. Pigs are usually standard at about 100 lb., while ingots are made to the buyer's special requirements. Special forms are produced for calking lead, etc.

Sheet lead may be rolled to any required width, length, or thickness. Sheets 8 ft. wide and (usually) 20 ft. long are standard.

Thicknesses corresponding to 4 lb., 6 lb., 8 lb., and 12 lb. are most common, although other weights are frequently specified for some special purpose, *ie.*, sheets for sulphuric acid chambers may be required to be rolled to a varying thickness, heavier at one end than at the other, so that the chambers may have extra metal on the bottoms, with the sides formed by simple bending.

Weights are given in lb. per sq. ft., with 1 lb. per sq. ft. equivalent to 1/64 in. in thickness.

TABLE 1. COMMON SPECIFICATIONS FOR LEAD

ASTM B29-43, Pig Lead

	Composition, %							
Type[1]	Ag[2]	Cu[2]	As+Sb+Sn[2]	Zn (Max.)	Fe (Max.)	Bi (Max.)	Pb (Min.)[3]	
1	0.0015	0.0015	(As 0.0015 max.)	0.0015	0.002	0.05	99.94	
2	0.002-.020	0.040-.080	0.002	0.001	0.002	0.005	99.90	
3	0.002	0.040-.080	0.002	0.001	0.002	0.025	99.90	
4	0.020	0.040-.080	0.015	0.002	0.002	0.10	99.85	
5	0.002	0.0025	0.015	0.002	0.002	0.15	99.85	
6	0.002	0.0025	0.015	0.002	0.002	0.25	99.73	
7	0.002	0.04	0.015	0.002	0.002	0.005	99.93	

Federal Specification QQ-L-171, Pig Lead

Grade	Pb (Min.)	Remarks	
A	99.9	For foundry use	
B	95.0	For weights, ballast, etc.	

Federal Specification QQ-L-201 (Amendment No. 1), Lead Sheet

	Composition, %							
Grade	Pb (Min.)	As+Sb+Sn[2]	Fe (Max.)	Bi (Max.)	Zn (Max.)	Cu	Ag (Max.)	
A	99.90	0.002	0.002	0.025	0.001	0.040-0.080	0.020	
B	99.50	—	—	—	—	—	—	

U. S. Navy Specification 47L1c, Lead Sheet

Grade	Pb (Min.)	As+Sb+Sn[2]	Fe (Max.)	Ni+Co[2]	Bi (Max.)	Zn (Max.)	Cu (Max.)	Ag (Max.)
A	99.90	0.002	0.002	0.008	0.025	0.001	0.080	0.020
B	99.50	—	—	—	—	—	—	—

Federal Specification WW-P-325, Lead Pipe

Pb, 99.7% min.; Zn, 0.002% max.

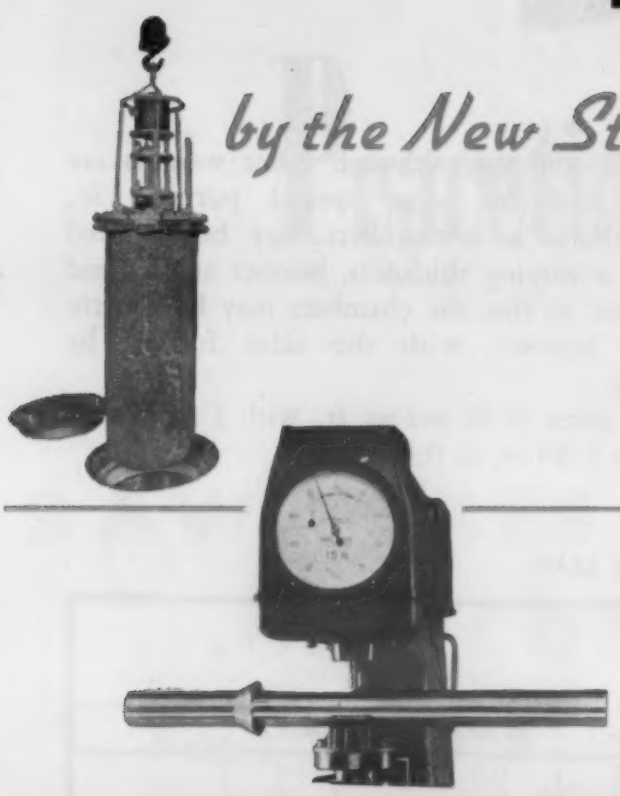
[1] *The designation by type numbers is for convenience in presenting tabular data and is not a part of the ASTM specification; for explanation of these type numbers, see Table 2.*
[2] *Values given are maxima unless otherwise indicated.*
[3] *By difference.*

(Continued on page 189)

You Can Now Add **Remarkable Wear-Resistance**

TO STAINLESS STEEL PARTS

by the New Stainless Surface-Hardening Process



What This Process Is—Stainless Surface-Hardening (Malcomizing) is a nitriding heat-treatment that gives stainless parts a surface hardness up to 96-Rockwell 15N or 73-Rockwell C. Penetration depths of 0.010 to 0.020 in. are readily obtained. There is no distortion problem with this process.

What Its Advantages Are—Stainless Surface-Hardening produces a "glass-hard" surface without seriously affecting the inherent corrosion-resistance of the stainless steel. This means that you can combine outstanding wear-resistance with the inherent corrosion-resistance and desirable physical properties of stainless steel.

What Steels Can Be Hardened—Both austenitic and martensitic stainless steels can be surface-hardened successfully. Types 18-8 and 12-14% chromium, and the free-machining grades, all respond well to this new process.

Where It Is Used—Surface-hardening increases by many times the life of stainless parts subjected to abrasive wear. In high-pressure steam valves, ball-bearings, dental drills, nozzles, pumps, bushings . . . wherever resistance to both wear and corrosion are required . . . the use of surface-hardened stainless parts should be considered.

For More Information—This reprint from STEEL will tell you more about the Stainless Surface-Hardening Process. A copy will be sent upon request. If you prefer, one of our metallurgical engineers will discuss the process with you. JMLCo-CSA1

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TABLE 2. COMMERCIAL TYPES OF LEAD

Type	Name	Remarks
1	Corroding lead	Refined to a high degree of purity so that no discoloration may result when it is used in the manufacture of white lead
2	Chemical lead	A name used for years to designate the undesilvered lead produced from Southeastern Mo. ores; it is highly resistant to attack by H_2SO_4 and other chemicals, and it is widely used in chemical manufacturing industries
3	Acid lead	Made by adding copper to fully refined lead[4]
4	Copper lead	
5	Common desilverized lead A	Terms designating fully refined desilverized lead[4]
6	Common desilverized lead B	
7	Soft undesilverized lead	A trade designation for the type of lead produced from ores mined in the Joplin, Mo. district

TABLE 3. PHYSICAL PROPERTIES OF LEAD

Type	Tens. Str., p.s.i.	Yield Str., p.s.i.	Elongation, %	Red. of Area, %	BHN	References[5]
Chemical lead	2760[6]	1640[6]	50	88	5.5	National Bureau of Standards Circular No. C447, p. 298, (Mat'l. No. 2632)
Chemical lead	2765	1643	50.2	87.9	5.5	ASM Metals Handbook, 1939 Ed., p. 1531
Chemical lead	2454	—	57	—	—	The Properties of Lead,[8] pp. 10-11
Chemical lead plus 0.06% copper	2961	—	42.2	—	80.9 Rb	*Ibid.*
Commercial lead	3000	—	33	—	4.3	National Bureau of Standards Circular No. C447, p. 298, (Mat'l. No. 2637)
Refined lead[9]	2100[10]	—	119	—	4.5 V	*Ibid.* (Mat'l. No. 2635)
Common lead	2093	—	43	—	63.7 Rb	The Properties of Lead,[8] pp. 10-11
Southeastern Mo. desilverized lead	1966	861	64.2	92.4	4.2	ASM Metals Handbook, 1939 Ed., p. 1531
Antimonial lead[11]	4000	2000	4.5	—	8	Metals and Alloys Data Book,[7] Table 283, p. 246

	Tensile Stress to Produce Creep, p.s.i.[12]					Fatigue Strength, p.s.i. at 5×10^7 cycles	Young's Modulus (ave.): 2×10^{-6} p.s.i.
	½% per yr.	1% per yr.	1½% per yr.	2% per yr.	2½% per yr.		
Commercially pure lead	150	230	280	320	350	400	Coef. of Linear Expansion (ave.), per F (50-212 F): 16.4×10^{-6}
Antimony-lead[13]	250	410	450	630	700	1000	

[4] *For the differences in composition, see Table 1.*

[5] *Because of the differences in both test data and procedure, the properties and their respective references are included*

[6] *0.5% extension; rate of strain: 0.026 in. per min. to yield strength, then 0.52 in. per min.*

[7] *By S. L. Hoyt, published by Reinhold Publishing Corp., N. Y., 1943*

[8] *Published by the St. Joseph Lead Co., N. Y., 1942*

[9] *Sample taken from extruded cable sheath 1 in. OD × ⅛-in. wall thickness*

[10] *Rate of strain 0.1 (in. per in.) per min.*

[11] *Composition: 94% lead, 6% antimony*

[12] *Table 284, p. 246, Metals and Alloys Data Book (q.v.)*

[13] *¾% antimony*

Compiled by Robert S. Burpo, Jr.

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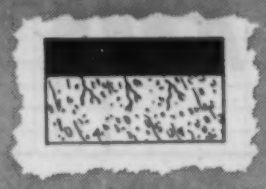
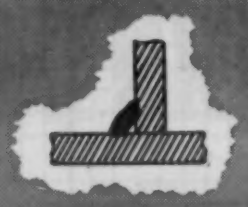


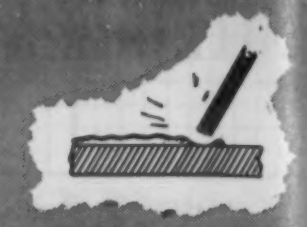
MICRO-CRACKS

Fine check cracks, invisible to the naked eye, will lower ductility and corrosion resistance.



INCOMPLETE PENETRATION

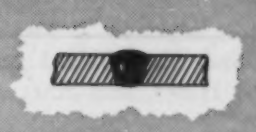
"Cold corners" particularly in vertical welding leave zones of weakness not readily found.



SLAG INTERFERENCE

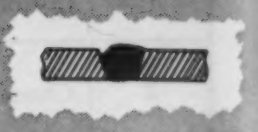
A ball of slag which runs ahead of the arc becomes a nuisance to the operator.

WHAT PRICE DEFECTS in ALLOY WELD METAL?



POROSITY

Sound metal is the only assurance of full strength and corrosion resistance.



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Improperly designed electrodes cause undercuts which may cause failure.

CONVEX FILLET

Poor fillet contour causes dangerous stress concentrations at the welded joint. Engineers insist on smooth bead contours.

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Defective welds don't pay off — if a weld fails, the reputation of your product or service is in jeopardy; even defects that can be repaired put you to needless expense.

When so much depends on so little, be sure — buy Arcos Alloy Electrodes.

FINGERNAILING

Fingernailing is caused by failure of electrode manufacturer properly to control his electrode processing.

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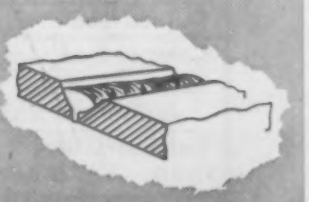

INCOMPLETE SLAG REMOVAL

Slag difficult to remove is often not completely removed and results in slag entrapment by subsequent layers.

If you would like to know more about the weld defects shown here, fill out and send us the coupon below.

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- ☐ New Arcos Reference Chart on Alloy Welding.

C-14

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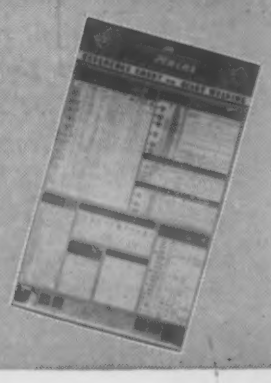
INFORMATION

Successful alloy welding often depends on having complete, correct information. Here is a text book in wall chart form — the Arcos Reference Chart on Alloy Welding. A copy will be sent you on request. The coupon is for your convenience.



engineering SHOP NOTES

Cutting Huge Castings by Oxygen Lance

By Wilbur Purcell,
Linde Air Products Co.

Where large chunks of metals are to be cut up for scrap, it is usually best to cut slots with an oxygen lance, then continuing with standard cutting machines such as oxy-acetylene. The oxygen lance can sever metal of practically any thickness.

A metalworking plant recently had to scrap a 100-ton steel casting. The cost of the usual method of disposing of scrap material used by this plant proved prohibitive. Oxygen lancing was decided on, and results were so satisfactory that the company similarly disposed of two other castings, each weighing 17½ tons.

Despite snow and sub-zero temperatures, the lancing operation was begun

immediately. It was started about 28 in. below the top of the casting, which at this point was 5 ft. thick. After a hole had been lanced completely through, the cut was continued to the bottom of the casting. The lance was meanwhile held at an angle to allow the slag formed from the cutting to run out of and away from the face of the cut. When the required number of these lance slots had been completed, the remaining web of material at the top of the casting was severed with a standard oxy-acetylene cutting machine. The resulting slabs, measuring 3 by 6 by 5 ft., were then easily cut again with the oxy-acetylene machine into suitable sizes for shipment.

In the accompanying photograph a huge 100-ton steel casting is being cut up for scrap with an oxygen lance. Three completed lance slots are clearly visible. Workmen standing on the casting are making a supplemental cut with an Oxweld cutting machine.

Simple Test for Lubricants and Bearings

by W. F. Schaphorst

Measuring of the interval that a machine continues to operate on its own momentum after the power has been turned off is a good simple test for either lubricants or bearings. Called the "stopping time" test, one of the prominent colleges has a lubrication testing machine of that type, built at the college.

The principle may be readily applied in any plant without purchasing extra testing equipment. Naturally, the longer the engine runs without power, the better. Should the engine be used for driving machinery, as engines usually are, test both with and without the load, using your own watch or stop watch. Entire motor driven, diesel engine driven and turbine driven—all can be tested in the same way.

The plywheel effect of pulleys on lineshafts and on the machinery itself is sometimes sufficient to cause the machinery to operate for some time after the power is shut off. By a little experimentation and observation "norms" or standards can be set up and hence lubricants and bearings graded accordingly.

The testing machine used at the college, mentioned above, consists essentially of a large rotor, roughly 30 in. in diam., weighing 2650 lb., supported between two bearings, one of which is the test bearing. This rotor is driven by a d.c. motor through a free-wheeling clutch. They have used speeds as high as 900 r.p.m. The only test bearing used thus far is a plain sleeve bearing without grooves, 2⅛ in. in diam. by 7 in. long, located at the outboard end.

The inboard bearing is a ball bearing. They feed oil through a reservoir located above the bearing through three openings with sight feed. The bearing itself may be rotated with respect to the shaft through 360 deg. Along one element of the bearing are located nine small holes connected by flexible tubes to pressure gages, so that it is possible to find the distribution of pressure along any element. Small thermocouples are used in these pressure holes for determination of temperature. They lead to a potentiometer.

Another device is a fixed pointer so arranged with respect to the outboard end of the shaft that it continually locates that end of the shaft. This is observed through a transit lined up with the bearing so that the point of the pointer shows the location with respect to the cross-hairs.

How MUREX FHP licked a tough job for us

Friends, did you ever know it to fail? I mean, just when your department gets running along smoothly, in marches a rush-rush job that they want done practically yesterday.

Take what happened to us last week: forty big engine bases that had to be fabricated right away, if not sooner—and each of them requiring 3860 lineal inches of welding. Tommy, our boss, took one look at the due-date on the job, and groaned.

"Okay," he said at last, trying to look cheerful. "Can do, I hope."

But after two units, we saw we'd never make it. They took 12 hours of welding time each, whereas we needed to make 10 hours or less to finish on schedule.

Whereupon I stepped up to Tommy, observing, "Look, I'm only a girl welder, and new around here anyway. But why are we using ordinary *all-purpose* electrodes on this job, when MUREX FHP would knock it off in very much less time? The last place I worked specialized in the fabrication of heavy bases and machine frames. We always used MUREX FHP on this sort of thing. Why don't we position these frames and . . ."

Tommy looked at me oddly. "Say no more, sister," he said. "Say no more. I should have seen right off the bat that this is a natural for downhand welding and good old MUREX FHP. But we were in such a rush, and I wanted to use up our stock of E6010 rods, and . . ."

The next day, a load of MUREX FHP came in. The first assembly was finished in *eight* hours as against the twelve the other rods took—*a saving of over thirty per cent!*

And, the MUREX man did us another good turn, by giving us a big new Wall Chart, which lists and classifies all of M&T's 30-odd electrodes. Now, when a new job comes in, Tommy consults the chart carefully to see which MUREX rod is the one to use...and he says we've saved lots of headaches that way.

If you have anything to do with arc-welding, you'd better send for the new Wall Chart for yourself. Just address:

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MUREX Electrodes

Felt for Polishing and Buffing

By Worth Colwell,
Felt Association, Inc.

Along with developments of new alloys have come refinements in materials and techniques for polishing and buffing with felt—facts that should be familiar to shop superintendents. Thousands of rock hard, durable felt bobs are used in finishing

airplane engine parts, such as connecting rods, cams, oil holes and other parts having irregular contours that a plain grinding wheel could not handle evenly.

One advantage of felt is the ease with which it can be shaped to fit the surface to be finished. Again, the wool fibre has a natural abrasive nature; also, it can easily be coated with abrasive grains. Possibly 85% of felt wheels in use are "set up"—coated with glue, then rolled in an abrasive of selected fineness.

An important quality is the elasticity of the felt, the cushioning property of the wheel equalizing the pressure, hence providing uniform cutting action. For buffing, which contributes a shiny surface without reduction in superficial roughness, the felt wheel is usually coated with a grease compound bearing rouge, tripoli or other fine abrasive.

Polishing wheels are made in at least four, sometimes nine, densities, depending on the hardness of the metal and cushioning properties needed from the wheel. They are operated at speeds of 6500 to 8000 ft. per min., hence must be carefully centered, trued and balanced.

Many are made in oversize discs from which the finished wheel is lathe-turned and ground to the finished size. Others are cut from sheet felt, which is also the source of felt bobs that are small, oddly shaped grinding and polishing tools used, often with flexible shafts, for finishing irregular contours and recesses in metal objects.

Polishing and buffing felt is made by extensive "fulling," a mechanical process of kneading wool under low heat, pressure, moisture and lubrication. This produces a fine-grained fibrous structure of remarkable hardness and strength, without chemical change in the wool fibres and without binders to act as stiffener.

Here are two interesting applications. Wool felt discs impart a high lustre to stainless steel plate, being mounted on flexible shafting and guided by hand (see accompanying photo), a use applied by Peter A. Frasse Co., New York. At the Linden Box & Crate Co., a circular saw is used in a crating plant where green, resinous lumber builds a highly resistant gummy film on all tool surfaces.

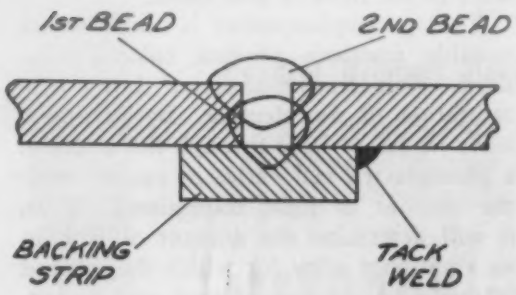
After grinding the saw to cut down rough surfaces, wool felt wheels are used to burnish, making a bright surface that tends to resist the resinous adhesions from the lumber.

Welding Airtight Tanks

by A. F. Davis,
Lincoln Electric Co.

One does not go about building atomic bombs every day, nor does the average welding shop busy itself with building equipment for it. However, some of the principles employed in welding vital equipment necessary for the manufacture of atomic bombs might well apply elsewhere.

Automatic arc welding by the "Lincolnweld" process hastened by 30 days the



manufacture of certain large and extremely important tank units. Obstinate difficulties presented themselves. The tanks were for storing dangerous emanations or residual matter that remained after scientific atom-harnessing operations and had to be absolutely leak-proof and air tight.

Manual shielded arc welding was first tried, but without success. The peculiar formation of the large, cup-shaped bottom design of the tanks defied effective joining with the electric arc, the plates frequently becoming buckled and distorted. Usual controls for distortion could not be used, as the tanks were fabricated inside a heavy concrete form at job-site.

At one of the three atomic bomb plants a series of 12 tanks, 75 ft. in diam. and 15 ft. high, were erected, supplemented by 4 smaller tanks of 16 ft. diam. Part of the tank consists of the shell and bottom section fused into a single cup-shaped container. These solid welded metal structures surrounded completely by heavy concrete were buried deeply in the earth.

Allowable distortion of the structure was less than 1%, and all joints had to pass rigid X-ray examination for porosity or other defects. Mild steel sheets, forming the cup shapes of bottom sections, were arranged in position against the concrete backing. Manual arc welding was first attempted to join the seams. This was okay where fit-up was good, but it was difficult to seal the joints where plate gaps varied up to ½ in. and plate distortion was excessive.

The problem was solved by automatic metallic arc welding, special holding and positioning devices, and effective welding sequence at the longitudinal and transverse joints. The ¼- and 5/16-in. sections, 6 by 20 ft., had ¼-in. backing strips tack welded along one end and one side of each section, the strips extending half way beyond the edge of the plate.

Sections were then placed in their relative positions in the concrete shell with one sheet overlapping the backing strip tack welded to the adjoining sheet, held in position by concrete blocks, 1 by 4 by 10 ft., placed 10 in. apart on each side of the joint. Shipyard clamping jacks also helped hold plates while welding. Before welding the longitudinal joints, the ends of the plate sections were first automatically butt welded. Normally, two passes of the welding wire effected 100% penetration of the joints. The beads were extended slightly beyond the ends of each seam.

The Lincolnweld unit was then positioned for the longitudinal seams, successive welds starting at the center of the structure, proceeding outward to alternate ends of the plates. Thus, each longitudinal joint was automatically welded, the first sealing beads being applied in a staggered sequence, first right—then left—of center, the weld penetrating ⅛-in. into the backing strip.

In case of extremely poor fit-up, finish welds were sometimes made in the third or fourth pass of the welding wire to completely seal the joint, but usually only two passes were needed. Finish welds were also started at the center seam, progressing in sequence from center to right, then center to left. Speeds for the first pass were 36 in. per min. with 5/32-in. bare wire electrodes, with machine at 650 amp., 31 v.; for the finish, the same speed and wire, at 625 amp., 34 v.

The only additional metal fabrication was manual welding of two pipe fittings

to the structure. The final step of construction was building of a concrete top.

The accompanying diagram is a cross-sectional sketch of a typical joint, showing the relative position of the backing strip and weld penetration. The photograph displays the uniformity of welded beads produced by this latest automatic arc welding process.

Electronic Sorter of Anodized Rivets

by Walter H. Bankard,
Glenn L. Martin Co.

In sorting anodized rivets that do not meet anodic specifications, an electronic device developed by the author improves in accuracy and speed over the former hand work methods. At the Glenn L. Martin Co. an electronic device has been

developed and attached to a standard rivet sorter.

It is a device of low voltage with a magnetically operated lever which is energized by completing an electrical circuit between the plate and the contact point. As the rivets pass through the separator, the contact point touches the head of the rivet and if not up to anodic specifications, a small relay is energized, the relay throwing out the rivet.

In the accompanying photograph appear the author and his device.

A polish for cleaning steel so as to bring back the original luster of machinery, tools or equipment can be made as follows: Dissolve 1 oz. of oxalic acid in a pint of boiling hot water. Then add 1 oz. of pumice stone (finely powdered) and 1½ oz. of strong ammonia. Place in a bottle. Moisten a piece of felt with this solution and rub the steel briskly. Be sure to shake bottle well before using.

—"Vancoram Review,"
Vanadium Corp. of America

Materials Inspection in Aircraft

by Richard B. Faurote,
Fairchild Engine & Airplane Corp.

With accumulating experience one learns constantly more about the newer inspection instruments such as used in an aircraft engine plant. Thus, advantages and limitations of the spectrograph are becoming better known daily. In the spectrographic laboratory, a chemist and his assistant have checked as many as 75 samples for from 8 to 10 elements in an 8-hr. work day. To do that by ordinary chemistry would require a large staff and much equipment.

Using beakers and solutions, a skilled chemist can measure the amount of molybdenum in a steel alloy in 2 days; with the spectrograph he can do it in 30 min., and be more certain of his results.

A shipment of damper rings for the Ranger 6-cylinder engine did not respond properly to heat treatment, a condition which might lead to failure in operation. Ordinary metallographic examination could not explain the peculiarity. A spectrographic examination showed 0.02% aluminum in the steel alloy, against allowable 0.005%. Only the spectrograph could show it quickly. The rings were discarded.

Among the limitations of the spectrograph is that carbon, sulphur and phosphorus in steel must be checked by chemical methods. Where the alloying element is over 10% accuracy of percentage, determination falls off greatly. Thus, bronze or brass, with high percentage of alloying elements, must be analyzed by other methods.

Other important tools in the chemical or metallurgical laboratory of an aircraft engine maker are the spectrophotometer, polarograph, electric titration apparatus, electrolytic equipment, and the diffraction X-ray. The first four go with wet chemistry—conditions in solution. The diffraction X-ray, one of the newest inspection tools, uses X-rays much as the spectrograph uses light rays. It shows elements present and in what manner they are compounded. Thus, in a synthetic rubber for a Ranger engine part it not only showed oxygen and zinc but that they were in the form of zinc oxide.

The spectrophotometer is useful where suitable reactions produce colored solutions. The density of color shows concentration of the element. By passing a wave length of light through the solution, a photoelectric cell varies its current with the amount of light transmitted. Thus, it will determine the amount of iron in an aluminum alloy for which the method is the most accurate, fastest and easiest. Laboratory assistants handle it as a routine check.

With the electrolytic method, depending on a flow of current through a solution, the element is removed from the solution and deposited on the platinum electrode, being used to test material in such bronze parts as bearings, valve inserts and guides. Electric titration makes tests where other speedy methods fail in solutions whose color is not clearly discernible. Electronic circuits detect small voltage changes within the solution, indicating quantitatively the amount of an element present by comparison with known standards.

The diffraction X-ray is the most complex of the new inspection tools. Its potentialities are just beginning to be understood, such as for strain studies and investigation of crystalline structure of matter. The apparatus is at least simple in principle, being similar to the spectrograph in that it records the patterns of a diffracted beam on film.

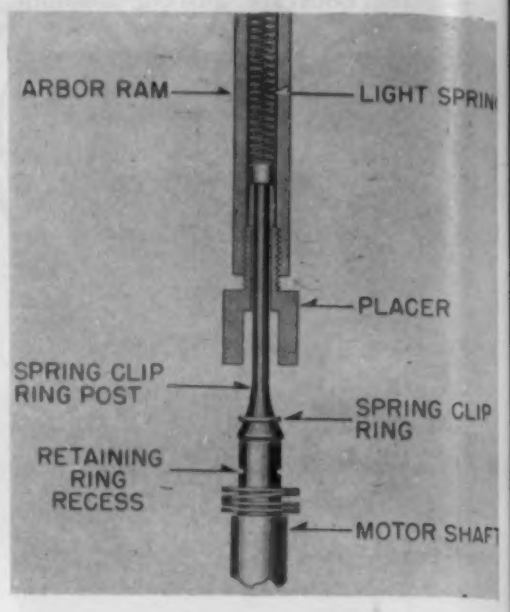
In the spectrograph, the beam is light and it is diffracted—broken down into the colors of its spectrum—by a prism or diffraction grating. In diffracton X-ray, the crystalline structure of matter does the diffracting and the beam is composed of X-rays instead of light rays.

(Courtesy of "Pegasus")

Spring Clip Ring Installation

by E. Lynch,
Westinghouse Electric Corp.

When spring clip rings were first used to secure washers on shafts, a ring was installed by placing it squarely on the end of the motor shaft and forcing it to expand and slide over the shaft to the ring



recess. This operation, which was done on an arbor press without tools, proved dangerous, unreliable, cumbersome and slow.

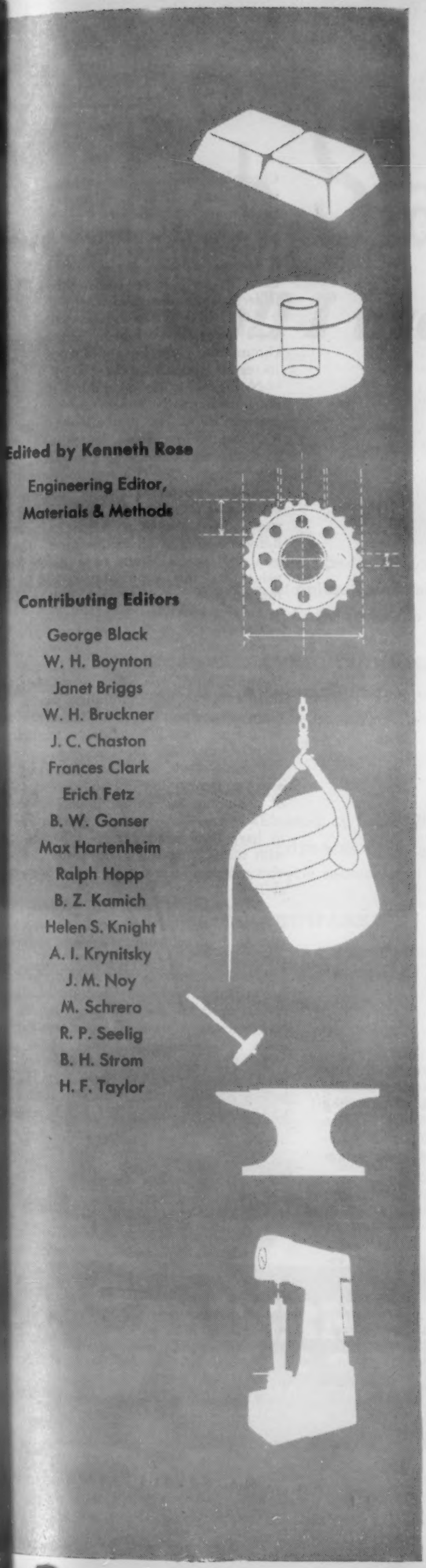
The tool, shown in the diagram, was developed to overcome this poor setup. This tool is made up from an arbor ram, placer, light spring with a header, and a spring clip ring post.

A light spring and header is inserted in the arbor ram; the ring post and placer assembly is then screwed into position. The light spring holds the ring post and clip ring in position once they are placed on the end of the shaft. The ring post, which is tapered at the lower end and cupped to fit the shaft end, carries and expands the ring clip as the arbor ram is lowered. The arbor ram is lowered slowly until the placer touches the ring and then quick additional pressure forces the ring over the end of the shaft and into the recess. There is a clearance of about 0.005 in. between the tapered post and the inside diameter of the placer.

This positive method has increased production and is much safer than the old method.

In view of current agitation to weld the crack in the Liberty Bell and close a crack in "Big Ben" in London, the following may be timely. Two church bells at Sao Paulo, Brazil, were welded with "Aeriweld" electrode and did not lose their original tones. First kerosene, zinc oxide and oxygen were used to find out the vein of the rupture. Then two ½-in. holes were made. Welding started from the center to the ends, there having been a heating with oxygen. When welding was accomplished, the bells were cooled slowly for 56 hr. inside a can filled with sand. This item was reported by Ernesto Trivellato.

—"The Stabilizer,"
Lincoln Electric Co.



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MATERIALS & METHODS DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.

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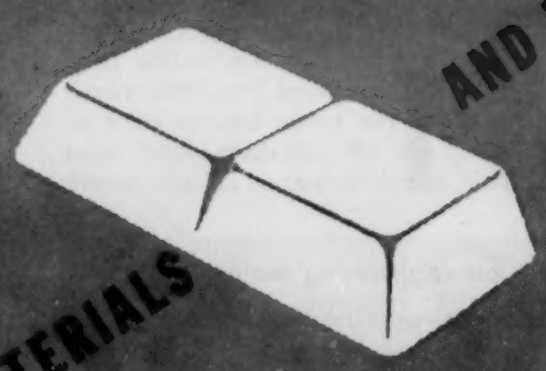

MATERIALS AND DESIGN

METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Hot Workability of Steel

Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

Increased use of alloying elements in steels led to the observation that many of the new steels were hot short in certain critical ranges, or at all hot-working temperatures. Stainless steels are particularly difficult to hot-work.

To evaluate the hot workability of steels, and to study the effects of the alloying element, a hot-working test has been devised in which the test bar is twisted while held at a definite temperature inside a furnace. The number of turns before failure at each temperature is a measure of the hot-workability of the steel at that temperature.

Deoxidation—All heats showed good hot-workability except the ingot iron lowest in carbon content. Apparently deoxidation practice does not materially affect the hot-workability of low carbon steels.

Carbon—Steels above 0.25% carbon have their maximum ductilities at 2350 F or lower. Lower-carbon steels show rising ductility with rising temperature. Straight chromium stainless steels show decreasing hot-workability with increasing carbon content, while with chromium-nickel stainless types the low-carbon steels are poorer than the 0.07 to 0.08% carbons.

Manganese—In general, manganese improves hot workability. It is necessary in steels to counteract the hot-shortness of sulphur. Manganese above 0.41% seems to give little additional improvement, especially in the presence of nickel, since the effect of these two elements is additive.

Sulphur and selenium—It is well known that sulphur affects hot-workability adversely. Of the ingots resulphurized for testing, the one lowest in sulphur shows much the best hot-workability. Although manganese is important for reducing sulphur red-shortness, bars high in manganese did not equal the ductility of those low in sulphur.

Chromium reduces the red-shortness
sulphur and selenium and makes 416-ty
steels quite hot-workable.

Phosphorus—Low-phosphorus steels sho
normal red-shortness curves.

Silicon—Silicon to 0.20% has li
effect in low carbon steels. Above 1.0
it decreases hot-workability.

Chromium—Below about 9.0%, ste
show lower hot-workability with increasi
chromium content, but above 9.0% ductil
increases, especially above 2300 F.

Nitrogen—In carbon and low-alloy steel
amounts normally present are so low th
hot-workability is not affected. In th
higher-chromium steels, ductility at hi
temperatures decreases with increased nit
gen.

Nickel—Nickel is one of the few el
ments that improves the hot-workability
steels. In quantities to 5.0% it improv
hot-workability at all temperatures. The 3
and 43% nickel steels have much low
values, but this is probably caused by th
formation of austenite rather than by nick
as an element.

Cobalt—Cobalt does not appear to affe
hot-workability.

Molybdenum—Molybdenum reduces th
hot-workability of carbon steels, but ha
little effect in 5% chromium steels. Fo
high chromium contents hot-workabili
with more than 2% molybdenum conte
decreases markedly above 2300 F.

Vanadium—In small amounts vanadiu
seems to have little effect on hot-workabili
of chromium and chromium-nickel steels.

Titanium—In alloy steels, titanium seem
to have little effect. It must be balance
with nickel, manganese and carbon to pr
vent a duplex structure, and poor hot-work
ability.

Columbium—Hot-workability of 5%
chromium-molybdenum steels and austeni
chromium-nickel stainless steels is markedl
reduced.

Lead—Lead has a detrimental effect o
hot-workability of low- and intermediat
carbon steels. It is additive with sulphur i
this direction. Chromium has a neutralizin
effect, as with sulphur.

Tin—Even in very small amounts ti
markedly lowers the hot-workability of low
carbon steels. The effect is less marked wit
higher-carbon steels, but is definitely present.

—Harry K. Ihrig. *Am. Inst. Mining Met. Engrs.* Tech. Pub. No. 1932, Oct. 1945. 29 p.

Prestressing Magnesium Alloys

Condensed from "The Journal of the Institute of Aeronautical Sciences"

The stress-strain curve, of importance t
designers, may be affected by cold-work o
plastic deformation. The decrease in th
proportional limit in compression becaus
of prestressing in tension, known as th
Bauschinger effect, is exhibited by magne
sium alloys, and, in addition, the stress
strain curves are influenced by the me
chanisms of deformation occurring in thes
alloys upon prestressing or cyclic loading

which Stainless *shall I use?*

MINE CARS?

Our mine cars handle a moist abrasive acid ore. Can we get a Stainless Steel that will stand up under the abrasion, and also resist the acid corrosion?

HEAT TREATING EQUIPMENT?

Our heat treating furnaces operate up to 1,500° F. Can we replace the hoods with Stainless? If so, which grade do you suggest?

CHEMICALS?

We are thinking of using Stainless Steel sheets for the lining of our dye vats. What grade and finish of Stainless Steel would you recommend?

MARINE HARDWARE?

Please send us your recommendation for the best grade of Stainless Steel for use in marine hardware, including rudders and fins.

Such questions on Stainless Steel selection are typical of questions which Eastern Stainless representatives answer every day. Eastern Stainless offers *all* the stainless grades you need for specialized applications of stainless steel sheet and plate. Consult Eastern on your selection problem.

Many of the answers are in the 96-page "Eastern Stainless Steel Sheet" handbook which, because of the great demand for copies, is now in its second printing. Write for your copy on your company letterhead.

AMLCO. E-A1

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At 480° F NU-BRAZE WONDER-FLUX NO. 4 starts to melt. Because of the extremely low melting point, this flux cleans and lines the joint well before the brazing alloy melts.

At 800° F this faster-acting flux is water-thin and so free-flowing that the molten brazing alloy eases it out of the joint completely.

NU-BRAZE WONDER-FLUX NO. 4 IS DIFFERENT FROM ANY SILVER-BRAZING FLUX ON THE MARKET—A NEW HIGH IN OXIDE-ELIMINATION.

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PRECIOUS METALS
193 Canal Street, New York 13, New York

See NU-BRAZE WONDER-FLUX NO. 4 demonstrated at the SHERMAN & COMPANY exhibit, booth No. B-315, at the Metal Show, Cleveland, February 4th to 8th.

Send me a sample of Nu-Braze Wonder-Flux No. 4. If it doesn't fill the bill, I'll send back the unused portion, and that necktie better be good!

NAME_____

ADDRESS_____ CITY_____

STATE_____ COMPANY_____

A series of tests were run with (1) magnesium alloy sand castings with random orientation and equal compression and tension yield strengths; (2) magnesium alloy extrusions with preferred orientation and with a compression yield strength 0.7 of the tension yield strength; (3) high strength magnesium alloy extrusions with preferred orientation and a compression yield strength equal to the tension yield strength.

Test bars were stretched or compressed to permanent deformations of 0.2, 0.5, 1.0, 2.0 and 4.0%, then tested in reversed stress. Some of the bars were tested immediately, others were held for two weeks at room temperature, and a third group was tested after a thermal treatment of 1 hr. at 350 F.

It was found that, while precompression of the specimens beyond the yield strength was not detrimental to the strength upon stress reversal, pretension caused a definite decrease in compression yield, especially if the initial deformation was above 2.0%. Room temperature storing allowed a substantial recovery of properties, while the original stress-strain curve was completely restored by the 1-hr. anneal.

Cyclic stressing up to the yield point will not influence the ability of a structure to carry original design loads within the allowable deformations, it was shown. The effects of cold-forming can be avoided in the case of alloys FS-1 and J-1 by forming at temperatures over 600 F. For high-strength alloys, forming is recommended prior to the final aging treatment. Operations such as stretching have a beneficial effect upon both the tension and compression yield.

While the tangent modulus curve may be lowered by prestressing, the initial modulus of elasticity remains constant at 6,500,000 p.s.i. This value is acceptable for commercial magnesium alloys. In actual tests under prestressing conditions, the modulus varied from about 6,000,000 to 7,000,000 p.s.i.

—F. A. Rappleyea, R. E. Perry & G. Ansel. *J. Aeronautical Sciences*, Vol. 12, Oct. 1945, pp. 448-454, 460.

Lead Products

Condensed from "Canadian Metals and Metallurgical Industries"

In the Toronto plant of the Canada Metal Co., Ltd., a large number of lead alloys are prepared for sale in the form of ingots and various fabricated products, including sheet, wire, pipe, lead-lined equipment and numerous other specialized items. Much of the pig lead used by this plant comes from Consolidated Mining & Smelting Co., Ltd., at Trail, B. C., whose product analyzes 99.997% pure lead, remarkable when it is considered that the purest lead recognized as to minimum by the American Society for Testing Materials is 99.94%, and applying to corroding lead, the purest grade.

Metallic values in oxides that develop during melting are recovered in reverberatory furnaces. Heat is applied to the top of the charge, and the fuel oil provides carbon for reduction of the oxides. In the furnace treatment of lead oxides, the furnace gases

(Continued on page 206)

AT BETHLEHEM IT'S *Steel* PLUS *Service*

An important division of Bethlehem's business is the making of high-grade carbon and alloy steels for every purpose. But it has always seemed to us that the proper handling and treatment of steel is as vital as the quality of the product itself.

To that end, Bethlehem offers the services of its technicians on problems involving analyses, heat-treating, and applications. It is a common thing for Bethlehem "trouble-shooters" to visit customers' plants, suggest the proper alloy for a given job, and discuss questions of hardenability, grain size, machining, etc.

During the war years, this service was accelerated in the interests of victory. The net result was two-fold: (1) a speed-up of production in many, many instances; (2) a fund of experience that is enabling our metallurgists to render even greater help during this reconversion era.

Bethlehem's customer relations are by no means confined to the sale of steel. If you have a problem that relates to steel, why not get in touch with us? You'll find that we offer both steel *and* service.

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are led into a large number of undegreased wool bags, 20 in. in diam. Shakers loosen the dust from the bags and it is collected, sintered and fed back into the furnaces.

In the melting department where large production of one grade is to be done, the lead is melted in two 25-ton steel, oil-fired melting pots. Becoming fluid at 327.5 C, the lead and its alloying elements are readily mixed by propeller type stirrers. The molten metal is then pumped into a gravity tank from which it is piped to the molds. Then they are cast into 60-lb. pigs.

The molds rest in troughs of cooling water and the molten metal poured into them. The molds are hinged at one end and, when the lead solidifies, the mold is thrown over onto a steel table where the ingot falls out. Five- and two-ton pots are used for melting smaller quantities per run.

Babbitt is often cast in round cakes; solder, for automatic baths, in bars with a hole for attaching to the feeder hooks; while other products may be cast in sticks. Certain presses for extrusion of wire operate at 1000 to 5000 p.s.i., it being possible to extrude a dozen wires at a time, the pig lead being in form of cylinders 11 in. long and 5 in. in diam. Other presses are used for extruding lead pipe from 1/16 to 12 in. diam.

Lead and its alloys are rolled cold easily, in the first pass a 4-in. slab being rolled to 1 in. The properties are not changed by the rolling except for tellurium lead, which work hardens. Under normal temperature antimonial lead is the strongest, but it loses this as temperature increases.

In the production of lead traps and bends, a special extrusion press with a fluted core is used, the two halves being fed from separate chambers, the two halves being welded together by pressure as they emerge from the die. Bends are made by varying the rate of advance of either ram.

—*Can. Metals & Metallurgical Inds.*, Vol. 8, Oct. 1945, pp. 30-32.

Corrosion of Iron and Steel

Condensed from a Paper of the American Society for Testing Materials

This report presents the results of the atmospheric corrosion tests on wire and wire product specimens after exposure for about eight years at 11 locations.

Three different groups of wires were tested: A, zinc-coated unfabricated wires; B, unfabricated wires carrying coatings other than zinc; and C, farm field fence.

There is a tendency for the light gages of wire to lose coating somewhat faster than the heavier gages; there is a very slight decrease in the rate of coating loss with increasing periods of exposure; the over-all annual loss of coating in oz. per sq. ft. of surface at Pittsburgh is 0.369; at Sandy Hook, 0.117; and at State College, 0.063.

There is no consistent indication that any one of the three groups loses coating at a more rapid rate than the other two, though it might be interpreted that Group C loses weight at the lowest rate.

The test procedure was to remove the specimens one-fourth at a time from each location, taking the last quarter when the coating was nearly gone but before rusting started. All of the removals have been made from Pittsburgh and Sandy Hook, and three-fourths from State College. Pittsburgh is the most corrosive of the test sites, hence more specimens have been removed from there than from any other location.

However, the corrosion resistant steel wires (high chromium and nickel-chromium) and copper covered steel wires (coating weights 7 to 9 oz. per sq. ft. of surface) that were removed from Pittsburgh after an exposure of five years showed no loss in strength.

Lead-coated wires after 6½ yr. showed no significant loss of strength, though they showed considerable pinhole rusting. Apparently, though pinholes mar appearance, they do not affect strength. In some cases lead-coated wires appear less corroded now than earlier, but at some locations, notably Pittsburgh, progressive overall corrosion is apparent.

The progressive loss of strength of zinc-coated wires after the zinc coatings were gone was about the same (or slightly slower) than the loss of strength experienced by uncoated wires.

—Report of Committee A-5, *Am. Soc. Testing Materials*, Preprint No. 4, 21 pp.

Silver-Thallium Bearing Alloys

Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

Studies of a group of silver-rich silver-thallium alloys were made to determine their suitability for bearings. Both fused and diffused alloys were studied, the latter prepared by electroplating, and heated 6 to 12 hr. at 500 to 600 C (930 to 1110 F) in an atmosphere of hydrogen. A diffusion layer 0.002 to 0.003 in. deep resulted.

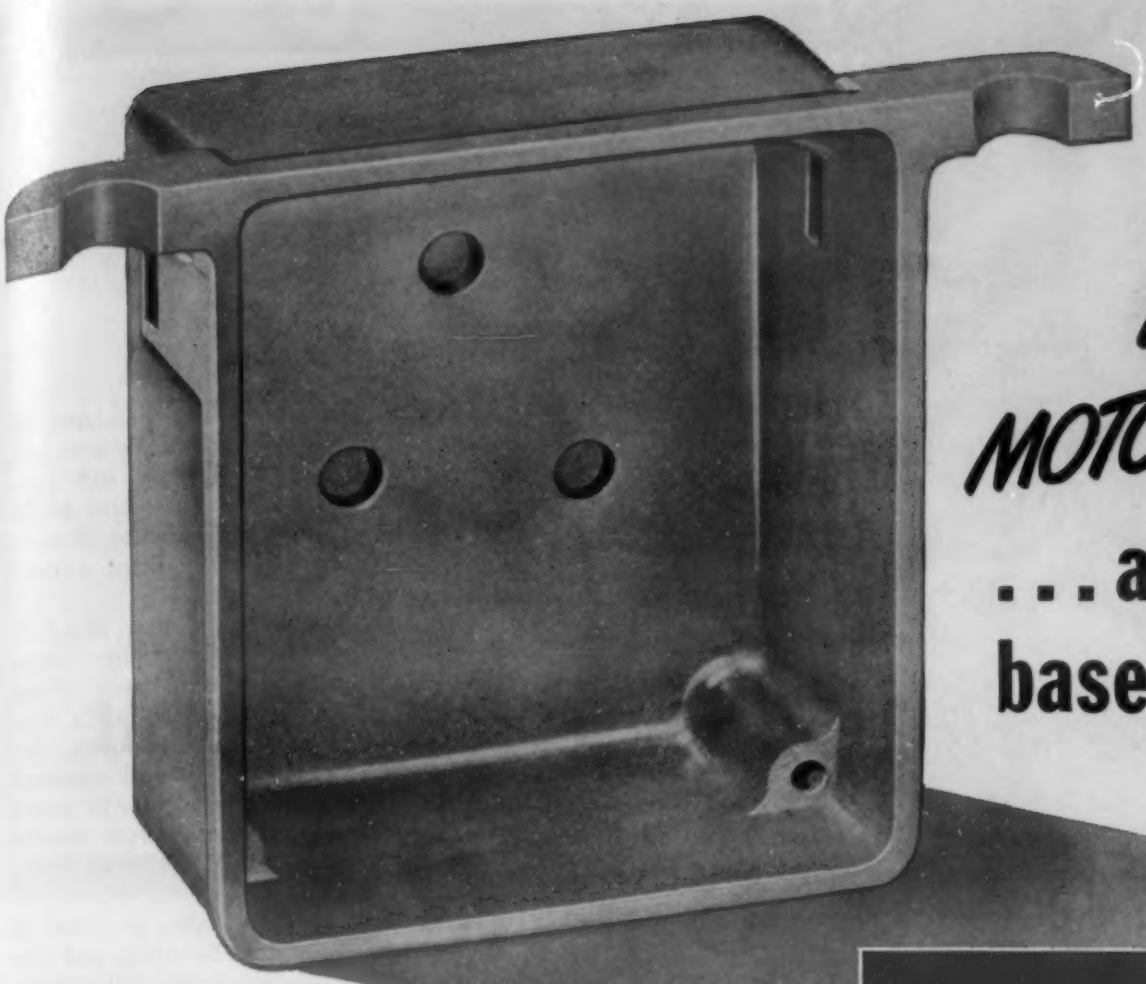
Cast alloys studied contained up to 10% thallium. Homogenizing treatments at 450 to 550 C (840 to 1020 F) were necessary to obtain true solid solution type alloys. The diffused alloys were prepared from electroplated deposits from cyanide or perchlorate baths. Homogenizing treatments were found helpful with those alloys also, eliminating internal stresses, preferred orientation, and non-uniform grain size.

Alloy layers obtained by diffusion contained 2 to 3% thallium. Diffusion of the plated deposits was improved by indium, the indium being deposited first, followed by thallium, then a second deposit of indium.

Tests made upon the specimens were run with both polished and with ground shafts. Amsler seizure tests and Underwood corrosion tests were used. A 2% thallium alloy was shown to have optimum anti-friction properties, while the corrosion tests showed extremely low rates of corrosion for these alloys, much lower than those for silver-lead or copper-lead bearing materials.

General Motors Bearing Tests were made with steel-backed bearings faced with 1.8% thallium-bearing silver alloy. The alloy was fused directly to the steel, then rolled and formed into half-shells. No fatigue failure of the bond was observed in the 48-hr. operation at 300 F. Presence of enough sulphur in the lubricating oil to cause silver to tarnish caused a slight tarnishing of the silver-thallium alloy also.

—F. R. Hensel. *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1930, Oct. 1945. 14 pp.



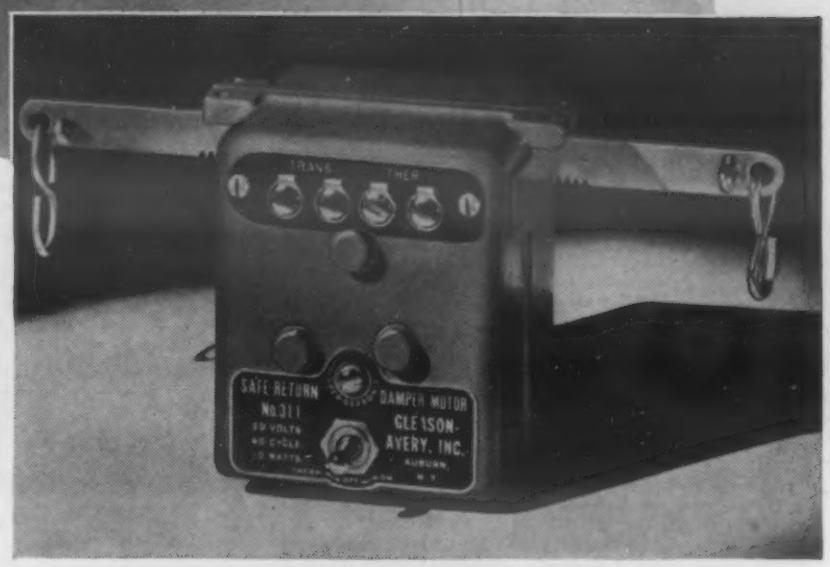
RIGID MOTOR HOUSING

...another Zinc base die casting

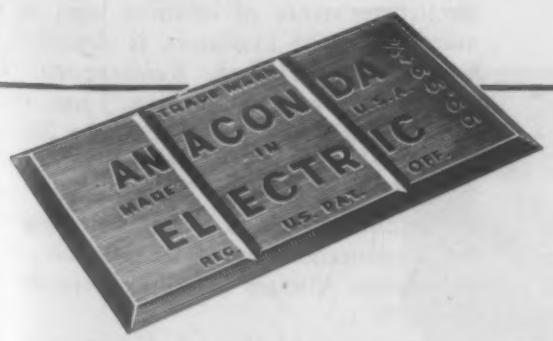
THIS STURDY die casting is one of a pair which form the housing of a Safe Return Damper Control Motor made by Gleason-Avery, Inc. of Auburn, N.Y. Among its advantages are strength, light weight, accuracy of dimension and economy of machining and finishing.

Other advantages of zinc base die castings include low die costs, relatively high speed production, and a lower over all cost per piece.

It should be remembered that an important factor in quality of the casting alloy is purity of the zinc used as a base. For this purpose you will find 99.99+ percent pure Anaconda Electric Zinc a thoroughly dependable metal. 45300



Safe Return Damper Control Motor made by Gleason-Avery, Inc., Auburn, N.Y. Housing consists of a pair of zinc base die castings like the one illustrated.



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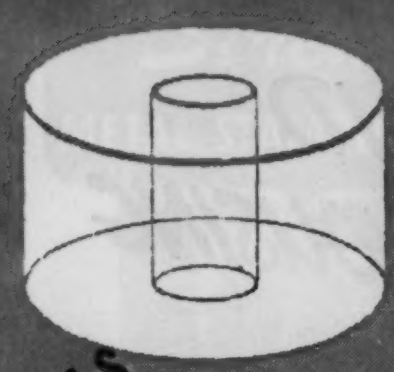

MATERIALS AND DESIGN

NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New types and forms of nonmetallic materials.

Synthetic Elastomers

Condensed from "Modern Plastics"

A range of comparatively new materials is available in the synthetic plastics when elastic properties are required. These flexible, resilient materials are sold under the trade name Vinylite. They are prepared by compounding vinyl chloride-acetate with a plasticizer to provide flexibility, which may vary from a soft, rubbery state to semi-rigidity. They possess excellent water resistance, high dielectric strength, oxidation resistance, resistance to weathering, and to oils, greases, and most chemicals. They are slow-burning, and can be formulated so as to be non-inflammable. A complete color range can be obtained.

These elastomers may be molded by compression or injection methods, the latter the more commonly used. They have gone into automotive weather stripping, tire valve caps, anti-rattle bumpers, furniture knobs, electrical plugs, kitchen appliances, printing rolls, pump suction cups, gaskets, washers, and floor mats.

Extrusions have been produced as a wide variety of functional and decorative items. Chemical laboratory tubing, beer tubing, electrical conduit tubing, temple rolls, typewriter platens, machinery bumpers, etc., are made as extrusions. Electrical insulation of high dielectric strength is made to protect overhead lines exposed to severe weather conditions, or exposed to chemical fumes, oil, grease, or alcohol.

Flexible sheeting and film, produced by calendering, are used in handbags and shoe uppers, waterproof shoe soles, wallets, belts, suspenders, waterproof coverings, waterproof and greaseproof ordnance packaging, protective insulation for aircraft lighting harness, transparent colored raincoats, shower curtains, window curtains and drapes.

Fabrics and elastomers are compounded to form coated fabrics useful against moisture, chemicals, and abrasion. The cloth will withstand flexing, and does not become brittle at low temperatures. It has found use as hospital sheeting, for tarpaulins, army ponchos, and non-skid aircraft floor mats.

The combination of easy fabrication, long life, resistance to sunlight, moisture, and chemicals, and wide range of colors indicates use in automobile upholstery, home and office furniture, and similar applications in postwar industry.

—S. J. Wilson. *Mod. Plastics*, Vol. 23, Nov. 1945, pp. 111-115.

Electrical Resistance of Ceramics

Condensed from "The Engineers' Digest"

A new method for measuring the specific electric resistance of ceramics used in the manufacture of insulators is described in *Physikalisch-Technische Reichsanstalt.* The samples used are circular discs, 5 mm. thick. The measuring electrodes have the form of a shield ring condenser, and are baked onto the surfaces of the discs. Platinum electrodes are recommended, as silver is not suitable for measurements on materials containing magnesium silicates if the temperature exceeds 450 C.

It was noticed that, if certain materials were subjected to higher temperatures, the current passing through them was accompanied by a flow of matter, which means

IRONING OUT A MATERIALS PROBLEM

A typical "postwar" item is this Silex Steam Iron illustrated. Like so many new products which are a part of our long-awaited civilian economy, this revolutionary home appliance makes prudent use of Durez phenolic plastics.

Why Plastics?

Notice the eye-appealing, heat-resistant handle. Exhaustive tests proved that plastics were better suited for this purpose than any other material known. Their use resulted not only in a better finished product but also in a product which could be produced very economically.

Why Phenolic Plastics?

Of all plastics, the phenolics are the most versatile. Naturally, this makes them the logical starting point for the design engineer with a materials problem. The handle of this Silex Steam Iron, for example, called for heat resistance, smart appearance, pleasant and hand-fitting "feel," moisture resistance, and excellent moldability . . . all inherent characteristics of phenolic plastics.

Why Durez Phenolic Plastics?

The more than 300 multi-propertied Durez phenolic molding compounds available today are the direct result of a quarter century's continuing research and product development on the part of Durez laboratory technicians. This rich background and the high quality of the materials themselves are convincing reasons why manufacturers in every field of industry look to Durez for the plastics that fit their jobs.

Experienced Assistance Available

Do you have a plastic materials problem? If so, see your custom molder. Wartime developments have endowed him with many new molding methods and processes so that his services are even more valuable than before. Should further assistance be necessary, the competent advice of experienced Durez service engineers and a wealth of proved product development data await your request.

Durez Plastics & Chemicals, Inc., 2713 Walck Road, North Tonawanda, N. Y.

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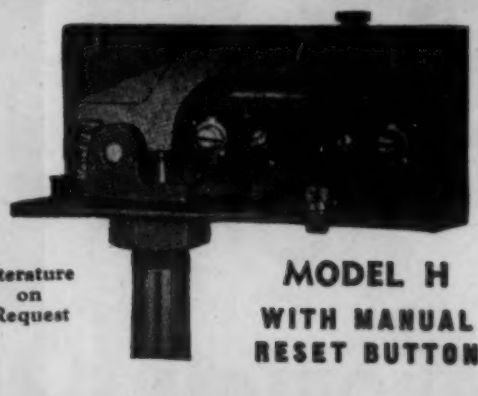
USE NO LIQUIDS . . . NO GASES



Literature on Request

MODEL H

WITH MANUAL RESET BUTTON

Improved High Temperature Safety Switch with Manual Reset Button. Available with switch normally closed for cutting off heat, stopping fan, closing valve — with switch normally open for lighting lamp or ringing bell—with single pole double throw switch . . . breaks heating circuit while closing alarm circuit. Sturdy, foolproof reset button operates from outside of case.

- **Accurate, Rugged, Dependable**
- **Corrosion and heat resisting tube**
- **Dial Pointer for easy setting**
- **Locking screw locks temperature setting**
- **Terminal plate has large screw terminals**
- **Snap-action Micro-Switch eliminates contact troubles**
- **Range 0-1400°F. Adjustable range 200-300°F**
- **Dimensions—5⅛" x 1¾" x 3"**

MODEL V-I

For lower temperature range from 0-300°F. Available for minimum of —100° to maximum of 600°F. Usual adjustable range 50-150°, operating differential may be as small as ±¼ or as large as ±5°. Adjustable by screw and dial inside case. (Sizes 2¾" diameter × 4¼" high)

MODEL D

Adjustable range 200-500°F. Temperature range 0-1400°F. For use where temperature must be changed to suit operating conditions. Turn outside knob to change temperature setting. (Sizes 5½ x 2¾ x 2¾").

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that ion-conductivity plays a part in the conductivity at these higher temperatures. If d.c. pressure is applied, the intensity of the current passing through the insulator decreases slowly, due to the electrolytic "cleansing effect."

According to the new techniques, two methods are used, one for high temperatures and one for low, with a.c. pressures in both cases as against d.c. for lower temperatures by the old method. In the high temperature range, a.c. of 50 cycles per sec. are used. The impedance is calculated from pressure and current measurements; the wattless component of the current, with regard to the total current indicated on the instrument pointed, can be neglected.

In the low temperature range, the loss factor and the dielectric constant of the material are measured on the Schering bridge and the specific resistance is calculated from a formula. It has been found that in the gap between the two groups of measurements, the curve representing the ohmic resistance, as a function of temperature, gradually merges into the curve representing the impedance. Measurements made under a pressure of 100 volts are sufficiently accurate.

Identical results are obtained whether the measurements are carried out at increasing, decreasing, or steady temperatures, and no changes were observed on the samples.

—E. F. Richter & W. Weicker. *Electro-technische Z.*, Nos. 7/8, Feb. 25, 1943, pp. 103-104; as abstracted in *Engineers' Digest* (British), Vol. 6, Aug. 1945, p. 218.

Melamine Industrial Molding Materials

Condensed from "Industrial Plastics"

Cured melamine-formaldehyde resin, again available for civilian uses, is one of the hardest of the synthetic resins produced today. It also shows high resistance to deterioration at extremes of temperature, and to the action of most solvents, to alkalies, and to weak acids. It can be used with many types of fillers, both cellulosic and inorganic. Electrical properties are excellent, and the material has achieved wide use as a high tension insulator.

Transfer molding is the preferred method for forming most parts from mineral filled melamine materials. It is especially desirable when the design requires close tolerances or use of delicate inserts. Most of the compound is semiplastic when it enters the mold cavity, thus eliminating stresses on the insert.

Whether transfer or compression molding is used, a good polish on the mold surfaces helps easy removal of the parts and improves appearance and tool life. Chrome plating of the molds to a depth of 0.0004 to 0.0007 in. helps in this respect.

When machining melamine plastics having a mineral filler, use of carbide-tipped tools is desirable. Turning has been most successful when done with a fast feed and comparatively shallow cut, with the work running at about 600 to 1000 surface feet per min. Carbide tipped tools were used.

Drilling may make use of carbide tipped drills, especially when the work is abrasive or semi-abrasive in nature, or they may be high-speed steel, preferably chromium plated. The lip angle should be between 40 and 50 deg., with a fairly large lip clearance. Drill speeds should be about 300 s.f.p.m., and best results have been obtained with fast feeds, although without excess pressure. Liquid coolants are of doubtful value, especially on deep holes.

Close tolerances sometimes require reaming, and here a very fast feed without the use of a coolant gives best results. The tool should operate at about 50 to 100 r.p.m. A blast of air may be used to clear the cutting edges. Taps should have a high polish, and should be chrome plated if possible. A 5 deg. negative rake will reduce friction. Soap coolants are helpful.

When weight must be reduced and ease of fabrication is important, wood flour filler is suitable as a replacement for mineral fillers. Electrical properties are retained. Molding temperatures run from 300 to 320 F.

—P. C. Fuller & W. A. Ward. *Ind. Plastics*, Vol. 1, Oct. 1945, pp. 10-13, 42.

Electrical Properties of Semi-Conductors

Condensed from "The Journal of Applied Physics"

The conductivity of a semi-conductor is its most important electrical property. Besides electronic conductivity, there is also ionic and electrolytic conductivity, which must be considered. These properties will vary considerably with different materials.

Equations are presented by which the electronic conductivity of a semi-conductor can be expressed.

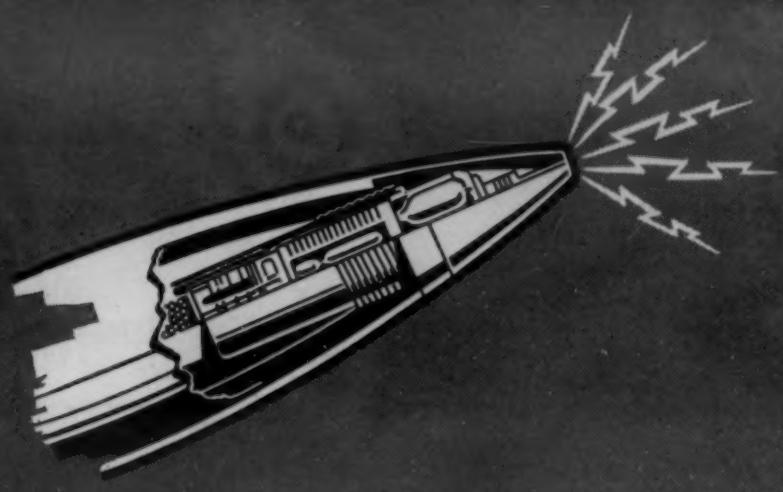
It is believed that the resistance of semi-conductors is greatly dependent upon their impurity content, and that practically all semi-conductors are good insulators at ordinary temperatures if they are in the pure state.

Deviations from stoichiometric proportions are the most important type of "impurity" which one has to consider when dealing with the electrical properties of semi-conducting compounds. There are available physical-chemical methods by which, in favorable cases, the degree of disorder may be determined as a function of the equilibrium conditions.

The combination of these measurements with the determination of the electrical conductivity and the Hall constant enables one to deduce the mean free path and the density of conducting particles as a function of the degree of disorder and of the temperature.

The absolute value of the mean free path is not uniquely fixed by these measurements because there is no reliable method of determining the effective mass of the particles. It is assumed, ordinarily, that the effective mass is the electronic mass.

—R. J. Maurer. *J. Applied Physics*, Vol. 16, Oct. 1945, pp. 563-570.



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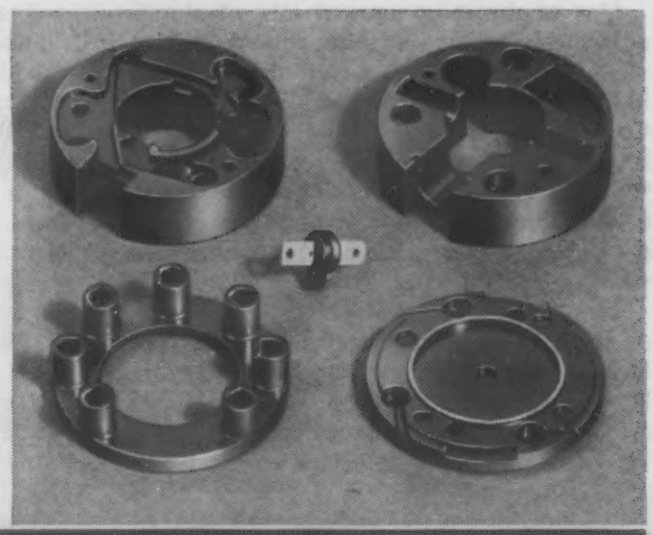

These small but highly intricate plastic pieces are vital parts of the now famous VT fuse.

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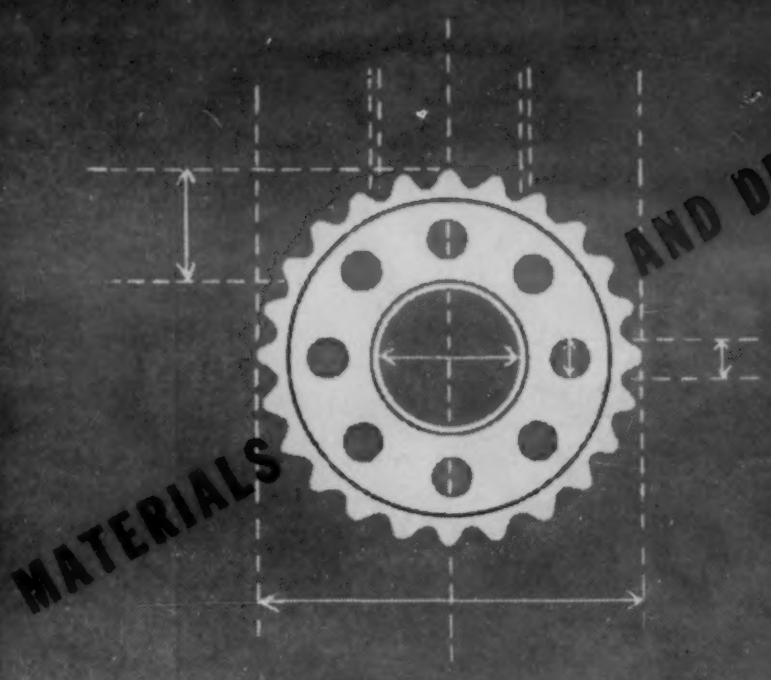


GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Welded Aluminum Tank Cars

Condensed from "The Welding Journal"

One of the most unusual jobs of aluminum welding is in the fabrication of all-aluminum tank cars for the chemical industry. General American Transportation Corp., Sharon, Pa., is building these of preformed pieces of 3S aluminum, ½- and 9/16-in. thick. The finished tanks are 31 ft. 4 in. long, and 87 in. in diam., welded by the automatic carbon arc process and manual welding with metallic aluminum electrodes.

The shell is of three pieces of formed aluminum, square sheared and butted to form a joint with a gap of about 1/32 in., but no greater than 1/16 in. The joints are first tack welded on the inside, using a 5% silicon aluminum shielded arc electrode.

Intermittent welds, 4 in. long, were applied 5 in. apart and a small tab of aluminum was also tacked to the edge of the shell at each end of the joint for later starting and ending the continuous bead in the carbon welding operation.

Then the shell is placed on a fixture and supported by 4 rubber-tired wheels for revolving for correct seam position. The "Electric Tornado" equipment then applies a solid bead to the inside longitudinal joints. A copper back-up bar, 3 in. wide and ½ in. thick, is placed on the outside of the joint, held tightly with a fire hose, inflated at 28 lb. pressure. The hose is placed along the length of the joint under the back-up bar and a channel frame arrangement.

Weld penetration averages ¾ of the joint, using 3/16-in. 3AS aluminum filler wire electrode and No. 520 flux; travel speed of the tractor unit is 12 in. per min., with wire-feed of 18 in. per min.; using 430 amp., 32 volts at the arc.

The same procedure applies to the outside beads on the longitudinal joints, omitting the back-up bar, the weld metal penetration being 75%, fusing with the weld metal being done on the first inside pass. The resultant joint averaged 11,200 p.s.i. tensile strength, with elongation of 41% in 2 in. X-ray tests showed no porosity.

Two aluminum ends of the same material are tacked into place with 3/16-in. metallic electrodes of 5% silicon aluminum alloy, with a 300-amp., 22-volt arc. Finish welding is done after preheating the work to 600 F, using a ¼-in. rod with 400 amp., 28 volt arc. Outside joints were then welded, using the same procedure as for the second (outside) pass on the shell.

Domes are tacked and welded on the tank with the aluminum alloy shielded arc rod. Both outside and inside beads are applied to the joints, the same as used for the inside welding of the heads. The outside brackets are welded to the shell with ¼-in. electrodes for hand welding aluminum.

—R. E. Haas. *Welding J.*, Vol. 24, Oct. 1945, pp. 907-909.

Skin-Stressed Boxcar Sides

Condensed from "Transactions" of the American Society of Mechanical Engineers

In a study of skin-stressed boxcar sides, test panels were subjected to a shear load applied with a geared jack, and measured with a 0- to 50,000-lb. dynamometer. The panels were fabricated with identical posts, side plates, and side-sill upper elements.

Panels tested were: No. 1, flat, unstiffened side section, 15-gage sheets; No. 2, flat sheets with two lapped longitudinal ribs; No. 3, same as No. 2 with vertical stiffener added; No. 4, 14-gage sheets with 6 lapped longitudinal stiffeners; No. 5, same as No. 4, with smaller stiffeners; No. 6, same as No. 4, but with 15-gage sheets; No. 7, same as No. 4, but with 16-gage sheets; No. 8, unstiffened flat side sheets, 0.100-in.

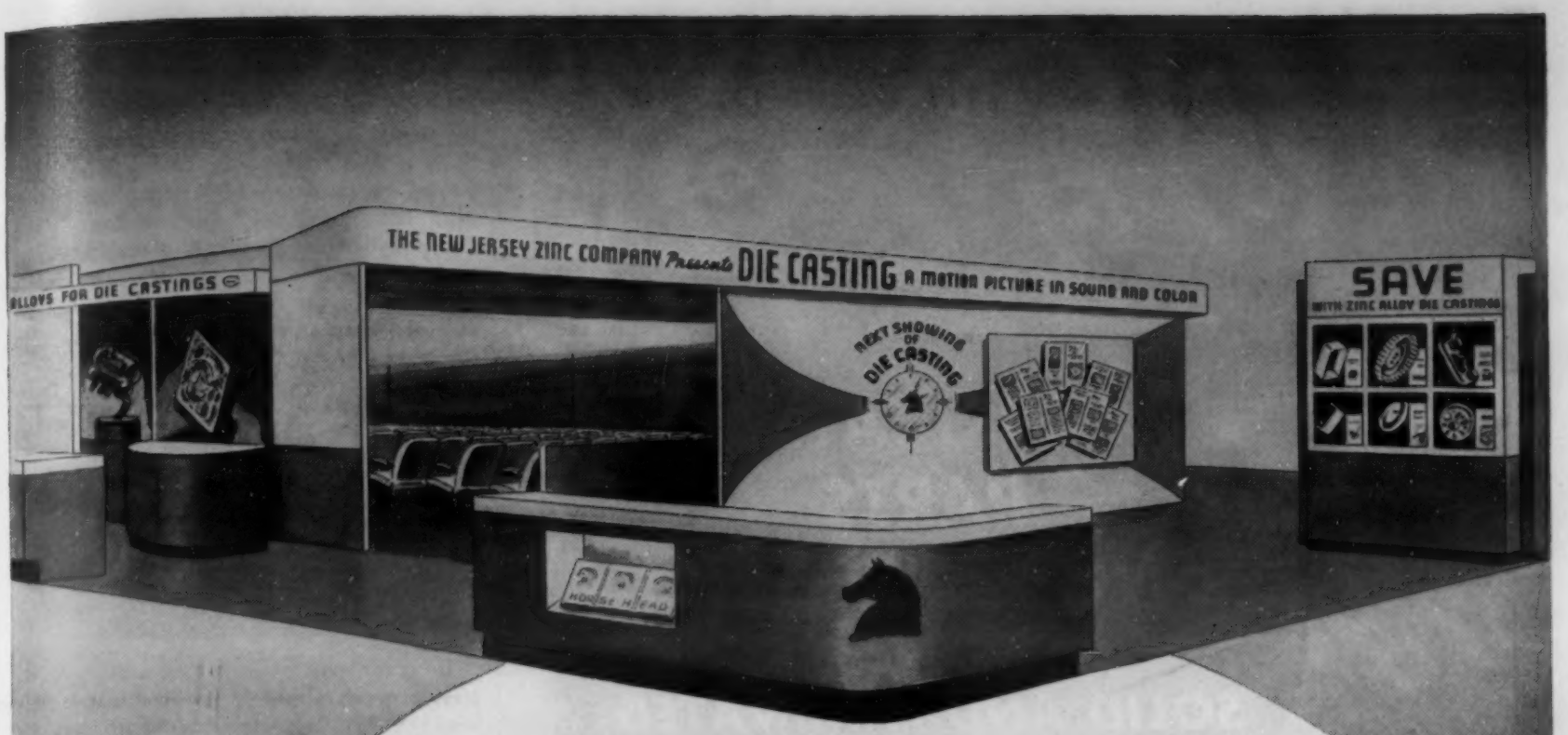
For panel No. 1, the theoretical critical shearing load was calculated to be 9250 lb. Actual critical shear load was 12,000 lb.

Panel No. 2 had a critical shear load of 13,150 lb. However, panel No. 6 had a critical shear load of 39,400 lb., thereby showing the advantage of a carefully designed girder.

Maximum theoretical critical shear stress encountered was the 4000 p.s.i. for test panels No. 4 and 5. The posts buckled before the actual critical shear stress could be attained.

Although having higher critical shear stresses, panels Nos. 4 and 5 are uneconomical since they far exceed the demand for a 50-ton boxcar. Panel No. 6 has a factor of safety of 1.88 which is higher than required, but the added sheet thickness would increase the time required for corrosion to affect seriously the factor of safety, and either panel No. 6 or 7 is more economical and desirable.

With a given stiffener spacing, the carrying capacity of a panel is proportional to the flexural rigidity of the sheet. Since the flexural rigidity is practically independent of the composition of the steel and is primarily dependent upon the plate thickness, the critical shearing load of the panels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At the advent of war we created an entirely new department for the manufacture of fabricated parts and assemblies. With a half century of experience to draw on, our training in precision work, the care and attention to detail necessary to production of fine decorative parts, the metallurgical experience and the understanding of fine finishing, proved of immense value in meeting the exacting requirements of industrial parts.

This department today is producing such critical items as collector rings, radio and radar parts, aircraft instrument parts, copper finned radiators for power tubes and other specialized fabrications.

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is not increased by the utilization of high-tensile material.

In an actual car side a great deal more load beyond the critical shearing load can be carried by development of tension fields. Such a tension field is, of course, accompanied by extremely high deflections. These high deflections result in rotation of the doorpost by the side sill and development of high fixed end moments which often result in failure of the doorposts or doorpost attachments in cars with unstiffened side sheets.

—V. L. Green & J. J. Drinka. *Trans. Am. Soc. Mech. Engrs.*, Vol. 67, Oct. 1945, pp. 561-567.

Aircraft Propellers

Condensed from a Paper of the Royal Aeronautical Society

In considering the future scope of aircraft propellers and propeller blade materials, the advances in power unit development must be considered. Propellers must be thought of in connection with the piston engine, with the straight jet with propeller as thrust augmenter, and with the gas turbine as the driving agent.

Hollow steel blades should eventually replace all other types on multi-engined aircraft, mainly on the score of better durability. Whether it will be possible to get down the thickness/chord gradings of around 16% at the spinner periphery, or provide the extreme dimensional accuracy demanded for high speed sections is as yet speculative.

Duralumin blades will continue for the time being as the blade material for the high speed fighter class, but will be severely taxed in reducing the thickness/chord grading at the spinner to below 20%, especially on piston engines.

Compressed wood blades will require very considerably improved surface coverings if they are to approach the durability of duralumin and even more so of hollow steel.

Solid steel blades offer possibilities in super thin aerofoil sections, and should be capable of obtaining 16% thickness/chord grading at the spinner. Their application may be more successful on certain sizes of turbine engines, their use being largely dictated by the progress of development in the reduction of vibration levels.

As long as the compressed wood blade can be fitted directly into a hub primarily designed for a duralumin blade, the former must always be the lighter propeller. The duralumin-bladed propeller will only compete with its wood-bladed counterpart when the root size of the former is reduced to a point that excludes the direct fitment of a wood blade, demanding a heavier hub to house the latter.

The hollow steel blade, with its relatively small hub, will definitely exclude the direct fitment of a wood blade, and as such will offset to a considerable amount the saving, blade for blade, between wood and steel. For the larger sizes, 15 ft. and upward, the hollow steel bladed propeller will come out considerably lighter than the duralumin-bladed type.

—L. G. Fairhurst. Paper, *Royal Aeronautical Soc.* Oct. 4, 1945. 35 pp.

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Forticel's excellent molding properties will be important to the designer and manufacturer as well as the molder. Practically invisible weld lines and great weld strength will simplify product design. The injection molding cycle—generally shorter than other cellulosics—and the wide molding temperature range will mean faster and more economical production. Forticel is compatible with cellulose acetate butyrate, but is not miscible with other cellulosics.

The addition of Forticel greatly enlarges the field of usefulness of the Celanese family of thermoplastics. By January first Forticel will be available for tests on selected applications. Increased quantities will be produced as rapidly as new plant facilities can be put into operation. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

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ODOR	None
HUMIDITY EXPANSION	0.4 percent
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MOLDABILITY	Molding cycle is generally shorter than other cellulosics . . . Uncritical molding temperature range

METHODS AND PROCESSES

MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Magnesium Alloy Microporosity

Condensed from "The American Foundryman"

An investigation was made of microporosity, concerned mainly with magnesium alloy sand castings. The sand used was a high permeability silica sand containing 6% sulphur, 0.5% boric acid, and 4% bentonite. Castings studied were standard D. T. D. test bars, top run bars with insufficient feeders, top fed bottom run bars, bottom fed bottom run bars, hot tear test bars, bottom run bulged bars, and pressure disks for testing before and after machining.

Density, mechanical tests, X-ray and micrographic examinations were made on the test bars to determine the nature and extent of porosity encountered.

The investigation showed that shrinkage is the main cause of porosity in magnesium alloys. The types of porosity encountered were intercrystalline, layer porosity, concentrated porosity, secondary pipe and annular porosity.

Dissolved gases which precipitate during solidification of the molten metal can increase the porosity in magnesium alloys although they are not the primary cause. Sulphur dioxide, carbon monoxide and carbon dioxide do not cause gas unsoundness. Hydrogen picked up either during melting or by reaction with moisture in the mold is the cause.

Corroded ingot metal will also introduce hydrogen unless thoroughly dried before charging. Gas can be easily removed by presolidification. Introduction of hydrogen causes a decrease in strength and an increase in porosity.

The freezing range of various alloys has no effect on the porosity. Fine grain material is stronger and more pressure-tight. The tendency of magnesium alloys to be porous is very similar to that of aluminum alloys, although it is more pronounced.

The very high cooling rate of magnesium alloys must be considered when risers are being located. Feeding cavities can be preheated to aid directional solidification. The metal will easily feed upward to parts of the casting where it is partly solid if the down-gate has sufficient cross-section.

At critical locations in the casting, the metal should remain as quiet as possible to prevent shrinkage and reaction with overheated sand. Dross and flux inclusions must be minimized by pouring as quietly as possible and by proper use of pouring basins and flux traps.

—E. A. G. Liddiard & W. A. Baker.
Am. Foundryman, Vol. 8, Sept. 1945, pp. 33-44.

Gas Annealing Malleable Iron

Condensed from "Foundry Trade Journal"

In the "as-cast" or "white-iron" condition, malleable castings are hard and brittle, due to the presence of combined carbon in the form of cementite. During the annealing process for the production of white-heart malleable iron, the object is to remove carbon so as to produce substantially pure and malleable iron.

From the nature of the process there is no reason why it should not be carried out in a suitably controlled atmosphere, so that, although it will decarburize, it will not oxidize the iron. The most readily produced and cheapest is the range of atmospheres obtained by partially burning a hydrocarbon-rich gas, such as town's gas.

Graphitization and the breakdown of the cast structure are functions of the temperature and time of anneal. With increasing temperature, the initial rate of decarburization increases, but after about 20 hr. and within 975 to 1025 C (1775 to 1875 F) the total weight removed per unit area of surface is more or less independent of the

220 TONS of STEEL CASTINGS *Wheelabrated in* 8 HOURS

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The answer to this problem was found by installing two Wheelabrator Special Cabinets for cleaning the heavy castings and two 48″ x 72″ Wheelabrator Tumblasts for the smaller work.

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A 2-pass Wheelabrator Cabinet is utilized for finish blastings after annealing, while the smaller castings, which can be tumbled, are cleaned in two Wheelabrator Tumblasts—green castings in one and annealed work in the other.

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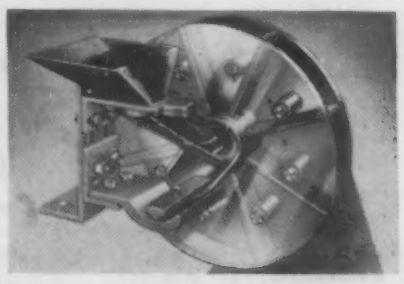

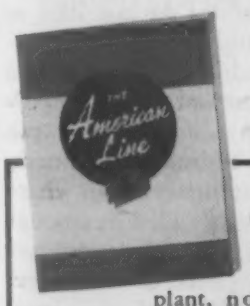

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annealing temperature. At 1050 C (2100 F), however, there is a significant increase in the amount of decarburization for annealing times between 20 and 50 hr.

At the lower annealing temperatures, graphitization increases with time, whereas at the higher temperature there would appear to be little increase in the degree of graphitization after the initial precipitation during the early stages of the anneal. In fact, at 1050 C there is a decrease in the number and size of the graphite nodules, with increasing time of anneal. Between 975 and 1050 C white cast iron consists of a saturated solution of carbon in gamma iron plus excess cementite.

The decarburization of white cast iron involves, at least initially, three processes, which proceed simultaneously: Oxidation of carbon at the surface of the casting, diffusion of carbon to the surface, and solution of excess cementite. It is safe to assume that the solution of excess cementite in unsaturated gamma iron is by far the most rapid, and thus does not control the rate of decarburization. Carbon is unable to diffuse sufficiently rapidly to the surface to maintain the minimum rate of oxidation or decarburization, and being the slower process is the controlling factor in the decarburization.

Simultaneously with decarburization and diffusion, graphitization is taking place in the iron. With increasing temperature the rate of diffusion also increases, with the result that the rate of decarburization during the early stages of annealing also increases. However, rate of graphitization also increases with temperature and, once it commences, the rate of decarburization falls appreciably.

—J. Jenkins & S. V. Williams. *Foundry Trade J.*, Vol. 77, Oct. 4, 1945, pp. 91-99; Oct. 11, pp. 113-116.

Vanadium in Cast Iron

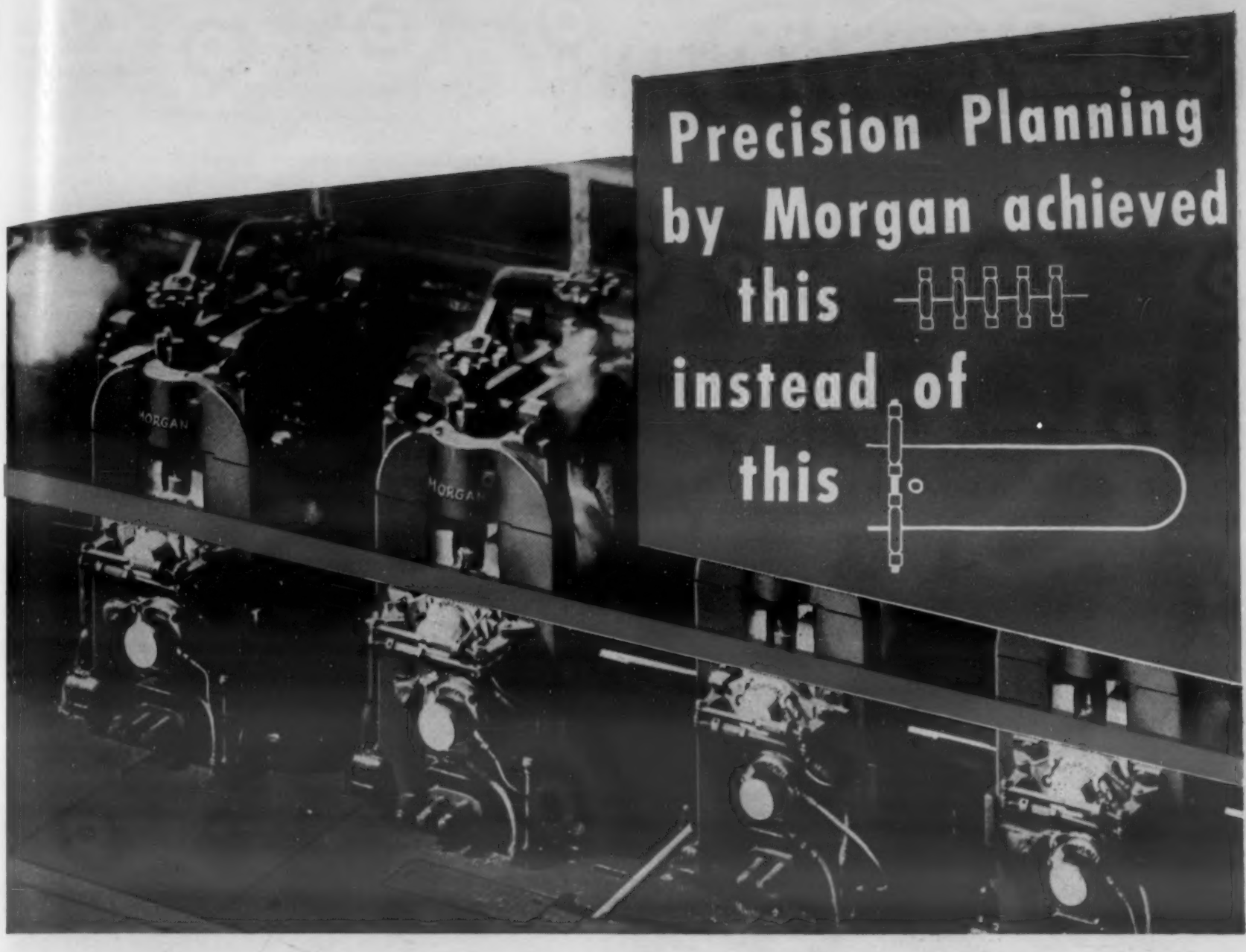
Condensed from "The Bulletin of the British Cast Iron Research Association"

While vanadium in steel alloying is well known, its use in cast iron has not received much attention. The properties of such metals, and the availability of scrap steel containing vanadium, make the subject of topical interest.

Vanadium may be added to cast iron as ferro-vanadium, containing 50 to 60% vanadium, as a ladle addition, or as a fine powder to the metal stream at the cupola spout. Ferro-vanadium diluted with pig iron is also useful for adding the element.

A more potent graphitizer than chromium, vanadium is usually added in amount less than 0.3%, since higher percentages affect castability. The effect of vanadium is to move the boundaries of the iron-carbon diagram to the right. As a scavenger alone, vanadium is of remarkable value, since it is a readily oxidizable metal, although the modern view of this action is that it does not perform a noticeable cleansing action.

Vanadium additions improve the mechanical properties of cast iron to a degree not



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exceeding 25% increase in strength, but depending upon the amount added and the composition of the base metal. The improvement may be due to its scavenger action, to its influence on carbides, or to the effect of it entering into solid solution with the carbonless constituent.

The hardness of a cast iron is increased by about 15 to 20 points Brinell for each 0.1% of vanadium present. In the presence of vanadium the carbides appear to be more stable and are slower to enter solution with the austenite. An example has been given of vanadium promoting higher strength at 400 to 500 C (750 to 930 F).

Small additions of vanadium produce a deeper and harder chill. Several sources claim that additions of vanadium improve the wear-resisting properties of cast iron.

Shrinkage and contractions are only very slightly affected by vanadium additions. The effect of the element does not appear to be altered by the presence of other carbide-stabilizing or hardening elements, such as chromium, molybdenum, or tungsten, which exert their own action independently.

—J. W. Grant. *Bull. British Cast Iron Res. Assn.*, Vol. 8, Sept. 1945, pp. 50-55.

Superheating Magnesium Alloys

Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

Considerable attention is being paid to methods of obtaining fine-grained castings with magnesium alloys. The factors influencing grain size are associated with superheating in foundry practice.

Grain refinement of the alloys has its maximum effect with a temperature range between 850 and 900 C (1560 and 1650 F). At higher temperature there is a tendency toward grain coarsening.

Superheating molten alloys for several hours at lower temperatures produces some grain refinement, but the time is reduced as the temperature is increased toward 850 C. At that temperature the refining effect apparently reaches a maximum at once.

The grain refinement effect of superheating is gradually and completely neutralized by holding the molten metal at lower temperatures after the superheating. Increase of the holding time before casting increases the coarsening of grain size.

Holding the melt at a given temperature for a sufficient length of time causes the same grain size, approximately, regardless of whether the material has been brought to that temperature from a lower one, or has been cooled to it after superheating.

Agitation at about 800 C (1470 F) assists grain refinement, but stirring at 700 C (1290 F) generally results in coarsening of the grain structure.

The grain size of an alloy varies with the grain size of the charge before melting, if all other factors are held constant, and the melt is not heated to high superheating temperatures. As the time held at superheat increases, or the temperature of superheat is raised, the effect of grain size before melting decreases and completely disappears.

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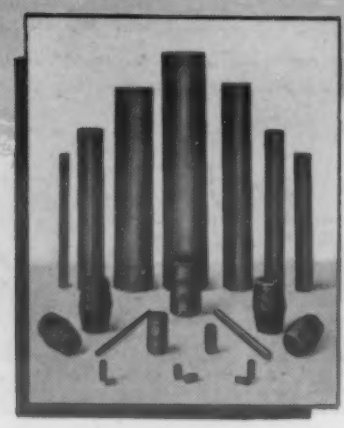

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Falls 50-50 Copper Nickel has a lower melting point than pure nickel that melts at 2646° F. and is more soluble than pure nickel. It is, therefore, within the range of the average brass furnace and its introduction is possible without overheating the alloy.

Its principal advantages are:

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Introduced at the beginning of a heat, it will be molten when the rest of the charge is liquid.

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Repeated superheating at temperatures of 850 to 900 C does not produce any appreciable change in grain size. The superheating effect upon grain size can be suppressed either by melting in a vacuum, or by treatment of the melt with a powerful deoxidizer, such as lithium or potassium.

Grain size is not appreciably changed by bubbling nitrogen, chlorine, or helium through the melt. Hydrogen produces a relatively fine-grained structure, but numerous blow-holes appear.

The effect of superheating upon grain size has been observed in magnesium-aluminum or magnesium-aluminum-zinc alloys containing manganese, or iron, but not in pure magnesium, magnesium-zinc, magnesium-manganese, or extremely pure magnesium-aluminum alloys. The effect is found to be associated with a decrease in the undercooling capacity of the alloys.

—N. Tiner. *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1935, Oct. 1945. 19 pp.

High Tensile Steel for Castings

Condensed from "Foundry Trade Journal"

Generally speaking, there are two ways of operating basic electric arc furnaces working on the two slag processes—to melt the charge and boil out the carbon to the required figure and remove the oxidizing slag before any deoxidizing additions are made, or to start the "killing" reactions by adding some form of deoxidizer before the oxidizing slag is removed.

Steel of the highest quality is more likely to be obtained consistently when deoxidation is commenced early in the heat when left until after the oxidizing slag has been removed, or the second slag added.

The phenomenon variously referred to as hair-cracks, flakes, and snow flakes is sometimes met with in forgings made from alloy steels. Working on the opinion that such defects were due to hydrogen, the means by which excessive amounts of hydrogen might find their way into the steel were studied. The slag-making material used at this time was burnt lime, which could have carried hydrogen into the steel.

The defect occurred most often in steels in which the carbon was fairly high, and in heats which had not received much boiling during the oxidation stage. Burnt lime was replaced by limestone, and the steel was boiled vigorously. The defect disappeared. Later it was decided to return to the use of burnt lime, but to continue boiling out to a carbon content around 0.1%, and this procedure proved to be successful.

Usually, the smallest grain size and the most uniform distributior. of pearlite and ferrite grains are desired. The grain size depends chiefly on the temperature of treatment, rate of cooling, and austenite-coarsening characteristics of the steel.

A large ladle addition of aluminum to basic electric steel is an advantage in helping to produce a fine grain size and in increasing toughness.

—W. West, C. C. Hodgson & H. O. Waring. *Foundry Trade J.*, Vol. 77, Sept. 20, 1945, pp. 47-52; Sept. 27, pp. 69-76; Oct. 4, pp. 101-104.

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MINUS-THREE-MESH Basifrit is a newly-sized, fast-setting type of grain magnesite. It is meeting enthusiastic, favorable response from open hearth men who are using it.

This product has the same high-grade chemical composition as regular Basifrit. Rich in residual magnesia content with adequate high-temperature bonds, it sets quickly in normal furnace operating temperature requiring little or no slag addition. It is ideal for burning in the working surface of new hearths and for resurfacing, repair and maintenance of old ones.

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Finally, minus-three-mesh Basifrit costs no more than regular Basifrit. It is, in short, "just what the doctor ordered." Include some in your next order of Basic Refractories products. Try it.

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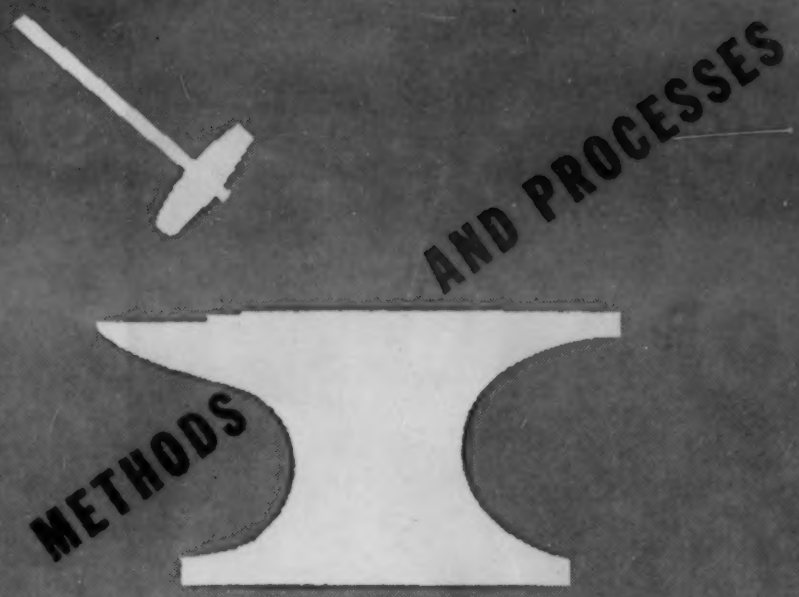

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Powder Metallurgy of Iron

A Correlated Abstract

When complicated shapes are to be made by pressing of iron powders, two processes are suggested by C. G. Goetzel, *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1920, Oct. 1945, 13 pp. The first, especially adapted to production of curved parts, employs regular level feeding and at times fractional molding. The second, for parts having one or more recesses or steps, calls for interrupting the molding process at certain points, or for the use of differential pressures.

Pressing of the metal powders should be done in the direction of the shortest extension of the piece to avoid too great loss of pressing force through internal friction. Curved surfaces, recesses, or offsets parallel to the shortest axis of pressure offer no difficulties.

Compression ratio, the proportion of the final relative density of the compact to the apparent density of the powder, must be increased when low apparent density powders are used for compacts of high density. Powders of relatively high apparent density are better adapted to quick-acting mechanical pressures, but such powders have an adverse effect upon uniformity and cohesion in complicated shapes.

The lower limit in pressures is fixed by the ability of the particles to adhere to each other, and may be as low as ½ ton per sq. in. for soft iron or copper powders, or as high as 50 tons for hard powders, such as steels. Upper limits are fixed by particle plasticity, entrapment and compression of air, press capacity, and die strength. For soft and plastic powders it is about 100 to 150 tons. With very thin cross sections it may be as low as 50 tons.

Present press capacity and die strength fix limits of about 60 tons per sq. in. for quick mechanical presses, and 100 tons for slower hydraulic presses.

Lubricants, usually powdered stearates, waxes, etc., with a commercial solvent, are mixed with metal powders. Closer packing of the mold cavity under a given pressure results.

By the use of hot-pressing, physical properties superior to those of cold-pressed parts can be obtained, according to O. H. Henry & J. J. Cordiano, *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1919, Oct. 1945, 10 pp. The application of heat during compression increases the plastic deformation of the powder particles, and the resulting compact is practically free of voids.

At present its use in commercial manufacture of precision parts is prevented by lack of (1) a die steel capable of withstanding high pressures at elevated temperatures; (2) a high temperature lubricant capable of preventing excessive die wear and welding of the compact; (3) a method of using a neutral or reducing atmosphere in the compacting zone; (4) a means of ejecting the hot-pressed piece into a neutral atmosphere until cool; (5) a means of confining the heat to the die cavity; and (6) a soundly engineered machine for mass production.

Heating during hot pressing may be done by induction, by passing a current through the powder mass, or by enclosing the die assembly in a furnace. The last method was used because of its simplicity. Electrolytic iron powder having an apparent density in the hall flowmeter of 2.4 grams per c.c., and precompacted cold at 20 tons per sq. in., was used.

Stearic acid dissolved in carbon tetrachloride was used as a die lubricant, and the hot-pressing punches and die parts were rubbed with flake graphite. The assembly was purged with dry nitrogen before bringing the furnace to temperature, after which hydrogen was substituted.

The precompressed compact was placed in the heated die and allowed to soak for 10 min., after which a pressure of 10 tons was applied for a given time interval, 50, 150, or 450 sec. After pressing, the piece was ejected through a chute.

Tensile strength, density, and hardness were determined for each specimen. Density increases markedly with increasing time and temperature, especially to 700 C (1290 F), and more slowly above this. Hardness

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STERLING ALLOYS Case History No. 27

To engineer a basket approximately 24" x 24" x 14" deep capable of carrying about 800# of work and to stand oil quenching from 1650°F., water quenching from 1600°F., and annealing at 1400°F. in recurrent cycles.

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A Sterling-designed articulated basket made in STERMET #1. After 9 months of uninterrupted service, the initial group of 6 baskets were found in perfect condition. Since then, a volume lot of this unit has been placed in service by the customer, resulting in sizeable economy of operating costs.

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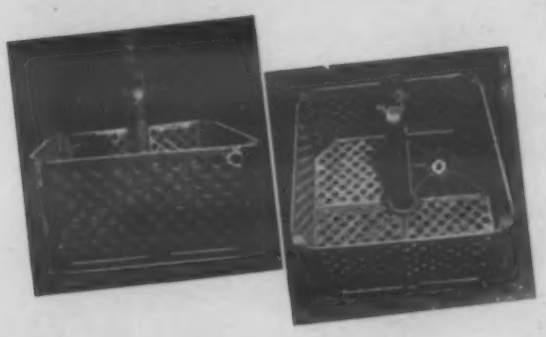

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STERLING ALLOYS, Inc.
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results are affected by density, but in general an increase is shown to 700 C, and a slight decrease due to annealing above this. Tensile strength increases due to intraparticle bonding, with maximum results of about 55,000 p.s.i. at 700 C.

Some of the reasons powder metallurgy is progressing rapidly, according to an article in *American Machinist,* Vol. 87, June 24, 1945, pp. 83-86, are:

(1) Use of iron-copper and pure iron self lubricating bearings made from powders saves copper by replacing bronze; (2) scrap losses in machining bar stock or forgings may be 30 to 70%; (3) processing of powder metal parts is generally rapid; (4) less time is required to make dies for molding powders than to tool up for production by conventional means; and (5) exact cost figures are unobtainable but important cost savings are indicated.

Sintered metals and alloys will generally not meet the usual specifications for the same metals and alloys in the cast or wrought condition. Despite the fact that powder metal parts may have lower physical characteristics than a cast or forged part, the powder metal part may give superior service. Therefore, the general opinion is that specifications should be set up only after performance tests.

Tolerances on almost all cylindrical pieces can be held to ± 0.0005 in. on the outside and inside diameters for sizes up to 2 in., and to ± 0.001 in. for diameters from 2 to 5 in. Length dimensions can generally be held to ± 0.005 in. for all sizes.

Most parts need little if any machining. But if it is required, the machining practice for non-porous parts approximates that for wrought materials of similar composition and hardness. Carbide tools are particularly recommended for long production runs.

With porous bearing materials, a dead sharp tool must be used to avoid spreading metal over the surface pores. Tungsten carbide or diamond tools are preferred in finish boring.

The front rake should be 8 to 10 deg., the side rake about 8 deg. Such tools are used at speeds up to 350 surface ft. per min. and finishing cuts at feeds from 0.003 to 0.005 in. Normal practice applies for roughing cuts.

High-Speed Zinc Plating

Condensed from "The Monthly Review" of the American Electroplaters' Society

With the improvements in high-speed continuous plating equipment, electrodeposited zinc is assuming greater importance for strip applications. Previous investigations of metal fluoborates showed high-speed plating possibilities, and further exploration of the zinc compound has resulted in the development of a bath that offers new advantages both in the high-speed continuous and the still tank plating applications.

Metal fluoborate baths afford simplicity of preparation, stability, ease of control, high cathode and anode efficiency, and approximate room temperature application.

In high-speed plating, zinc may be de-

(Continued on page 229)

AW

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posited at a rate higher than with other commonly used acid baths. In tank and barrel plating, it may be deposited on cast or malleable iron to give good adhesion, uniform coverage, and an attractive light colored finish.

Zinc fluoborate, a comparatively new chemical in the modern electroplating field, is available as a clear, colorless liquid, having a specific gravity of about 1.55. Like the other metal fluoborates, it is marketed in the form of a "concentrate," a solution containing about 50% zinc fluoborate and 3% free boric acid.

For high-speed plating, such as is required in continuous wire, strip or sheet applications, the following bath composition has been found satisfactory:

	g. per l.	oz. per gal.
Zinc Fluoborate, $Zn(BF_4)_2$	300	40.2
Ammonium Chloride, NH_4Cl	27	3.6
Ammonium Fluoborate, NH_4BF_4	35	4.7
Licorice	1	.134

This bath may be more dilute for tank and barrel plating and modified slightly to secure desired results. A pH range of 3.5 to 4.0, determined colorimetrically, has been found satisfactory for plating zinc from the fluoborate bath.

Of the number of addition agents tried, excellent results have been obtained with licorice at a concentration of about 1 g. per l., or glucose at a concentration of 80 g. per l. Licorice is preferable in high-speed plating because of the lower resistivity of the resulting solution, but Karo is preferred for low current density plating, as it improves the covering power and gives smoother, finer-grained deposits.

Optimum operating temperatures range from 80 F to 130 F. Low temperatures increase the throwing power, while higher temperatures tend to lower the resistivity of the bath. In high-speed plating, therefore, temperatures in the neighborhood of 130 F are recommended.

For best results in high-speed plating, the anode area should be about equal to the cathode area and larger if possible. For tank plating the anode area should be twice the cathode area.

Control of the bath is maintained by checking the zinc metal, the ammonium chloride and the ammonium fluoborate contents, the pH and the concentration of the addition agent.

—A. E. Carlson & M. J. Krane. *Monthly Rev.*, Am. Electroplater's Soc., Vol. 32, Oct. 1945, pp. 1022-1026.

Recrystallization of Aluminum

Condensed from "Metallwirtschaft"

The recrystallization processes that take place in the practical hot-rolling of aluminum ingots to different thicknesses at different temperatures were investigated for 99.0 aluminum and 99.5% aluminum purity. No recrystallization took place for low rolling temperatures (tempering), generally below 300 C (570 F). Part recrystalli-

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zation takes place at higher temperatures and larger thicknesses of the rolled sheets, and extruded pieces recrystallize hereby less easily than chill mold castings.

Extruding partly produces a coarsely recrystallized structure. Recrystallization of cold-rolled sheets depends on the type of previous hot-deformation. If in this latter process a mechanical strengthening has occurred, recrystallization is accelerated, depending on the original grain size; low recrystallization temperatures and medium rates of deformation (60%) increase the recrystallization times considerably.

Recrystallization phenomena in hot-rolling are ascribed to the same circumstances. No difference in the recrystallization could be found between 99.0 aluminum and 99.5% aluminum.

The tempering, which does not lead to recrystallization, is carried out mainly to obtain high values of elongation of about 15 to 25% at medium ultimate strengths of 11 to 14 kg. per sq. mm. These values of elongation are considerably higher than in aluminum, which has obtained the same strength by cold-rolling.

To obtain the optimum values of elongation a higher annealing temperature must be applied; the time of annealing is of great importance, a difference between one and six hours corresponds in its effect to a temperature increase of 35 C (65 F), *i.e.*, instead of increasing the temperature by 35 C, the annealing time is increased from 1 to 6 hr.

The material should be heated in electrically heated furnaces with air circulation, as this gives the sheets the smooth surface necessary for deep-drawing.

—K. Kaiser. *Metallwirtschaft*, Vol. 22, Nov. 20, 1943, pp. 503-507.

Heat Treating Aluminum Alloys

Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

While considerable data have been assembled upon the effect of time, temperature, work-hardening, and composition upon mechanical properties and corrosion resistance of aluminum alloys, it is not well unified and generalized. To find a common relationship between these results, a series of tests was made with 24S alloy, in sheet form, cut into test strips 1-in. wide. The pieces were solution heat-treated in a salt bath at 495 C (925 F) for 30 min., quenched within less than 1 sec., in water at 22 C (72 F), and aged at room temperature for more than 2 weeks.

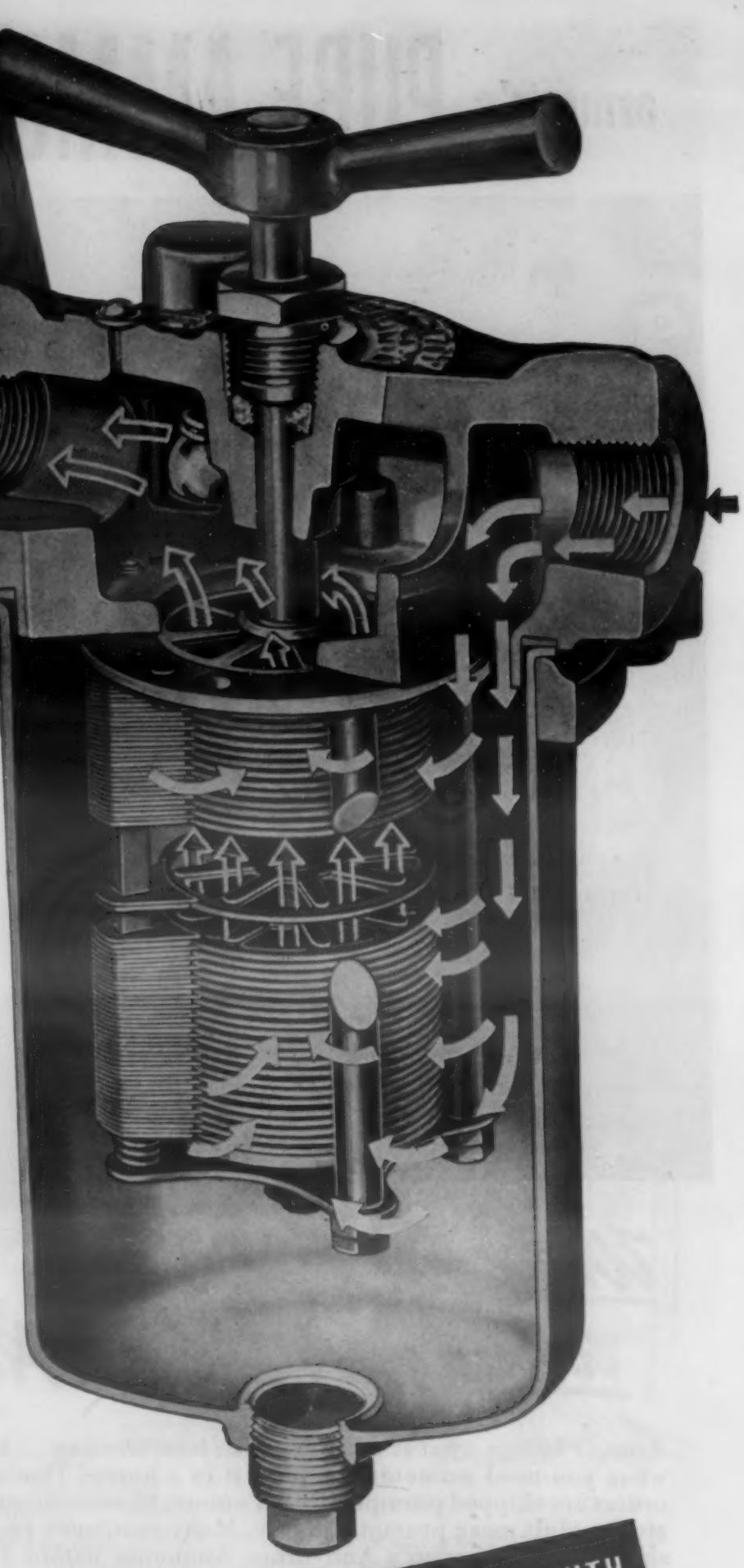
When the results were correlated, it was shown that the effect of precipitation time and temperature on both the initial change and ultimate maximum mechanical properties, and initial and ultimate susceptibility to corrosion can be expressed in the form of an equation:

$$t = K \cdot 10^{m/T}$$

in which t is the time in hours and T the temperature of aging in degrees absolute, and m and K are constants.

They can then be plotted on the same coordinates, summarizing the large volume of data, and assisting in choice of optimum precipitation time and temperature.

WHAT YOU'VE SAID YOU WANT IN A FILTER YOU GET IN AN AUTO-KLEAN



WE asked a large number of manufacturers to list, in order of importance, the features they desire most in a fluid-cleaning device.

Here's what the men in charge of production considered most important:

1. Efficiency
2. Simplicity and compactness
3. Service from supplier
4. Ease of maintenance
5. Capacity
6. Continuous operation
7. Maintenance cost

Now consider the Cuno Auto-Klean. (1) It's *efficient*—positively stops all solids larger than minimum size specified. (2) It's simple and *compact*—actually smaller in size than other filters handling the same volume at equal porosity. (3) There are 21 sales engineering organizations throughout the country to provide service. (4) It's easy to maintain—is cleanable just by turning a handle, or by motor—nothing to replace or remove for cleaning. (5) Flow capacities range from a fraction of a gallon to thousands of gallons per minute. (6) Production is never delayed—the filter is continuously cleanable without interfering with flow. (7) Maintenance cost is low because the all-metal filter element will last as long as the equipment on which it is installed.

Cuno Auto-Klean—an all-metal, non-collapsible filter—is being used successfully on a variety of applications . . . from high-pressure to gravity-feed systems . . . from straining river water to filtering heaviest fuel oil.

You'll find filter selection information and specifications on the Cuno Auto-Klean in SWEET'S—or write us for Mechanical and Process Industries Catalog, Cuno Engineering Corporation, 455 South Vine Street, Meriden, Connecticut.

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The character and intensity of corrosion, as a function of precipitation time, may be correlated with the idea of age-hardening whereby grain-boundary precipitation and general precipitation take place in stages. Grain-boundary precipitation results in intercrystalline corrosion, which increases to a maximum at the time when general precipitation begins, then decreases until it attains a constant low value, indicating that the general precipitation reaction is complete.

Maximum tensile strength and maximum yield strength occur simultaneously when precipitation temperature is properly controlled. Both attain a simultaneous maximum after treatment for 2 hr. at 210 C (410 F).

It is possible to define the time and temperature permissible in high-temperature applications since initial changes in properties may be expressed by the equation given. This is especially true with regard to initial susceptibility to intercrystalline corrosion.

—W. D. Robertson. *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1934, Oct. 1945. 12 pp.

Thread Grinding

Condensed from "Engineering Inspection"

The first wheel employed for thread grinding was a gray iron disk charged with diamond dust, mounted on a spindle fixed to the cross side of a lathe and used to correct previously turned threads. Originally sand stone was used for general grinding, but later emery and corundum were employed. The next important step was the discovery of silicon carbide in 1893. It was not until the vitrified wheel was produced that marked progress was resumed.

The first machines were modified lathes, on which the usual tool posts and tools were replaced by the grinding wheel spindle, inclinable to suit the normal helix angle of the thread to be cut. Much wheel dressing was needed to obtain the correct thread form. In 1924 came the single point dresser capable of producing sharp V, acme and other trapezoidal forms, but still producing only the flanks and root of the desired thread form.

Then came the well known caliper type gage which demanded the inclusion of thread ground anvils. Then came a machine admirable for the grinding of thread profiles, having an accurate lead screw, a single wheel of special shape with the radius carefully matched with the pitch to be cut, and a specially developed cam and stylus. Later the anvil was replaced by the grinding wheel and the wheel by a correctly shaped diamond, producing a multi-thread formed wheel of great accuracy.

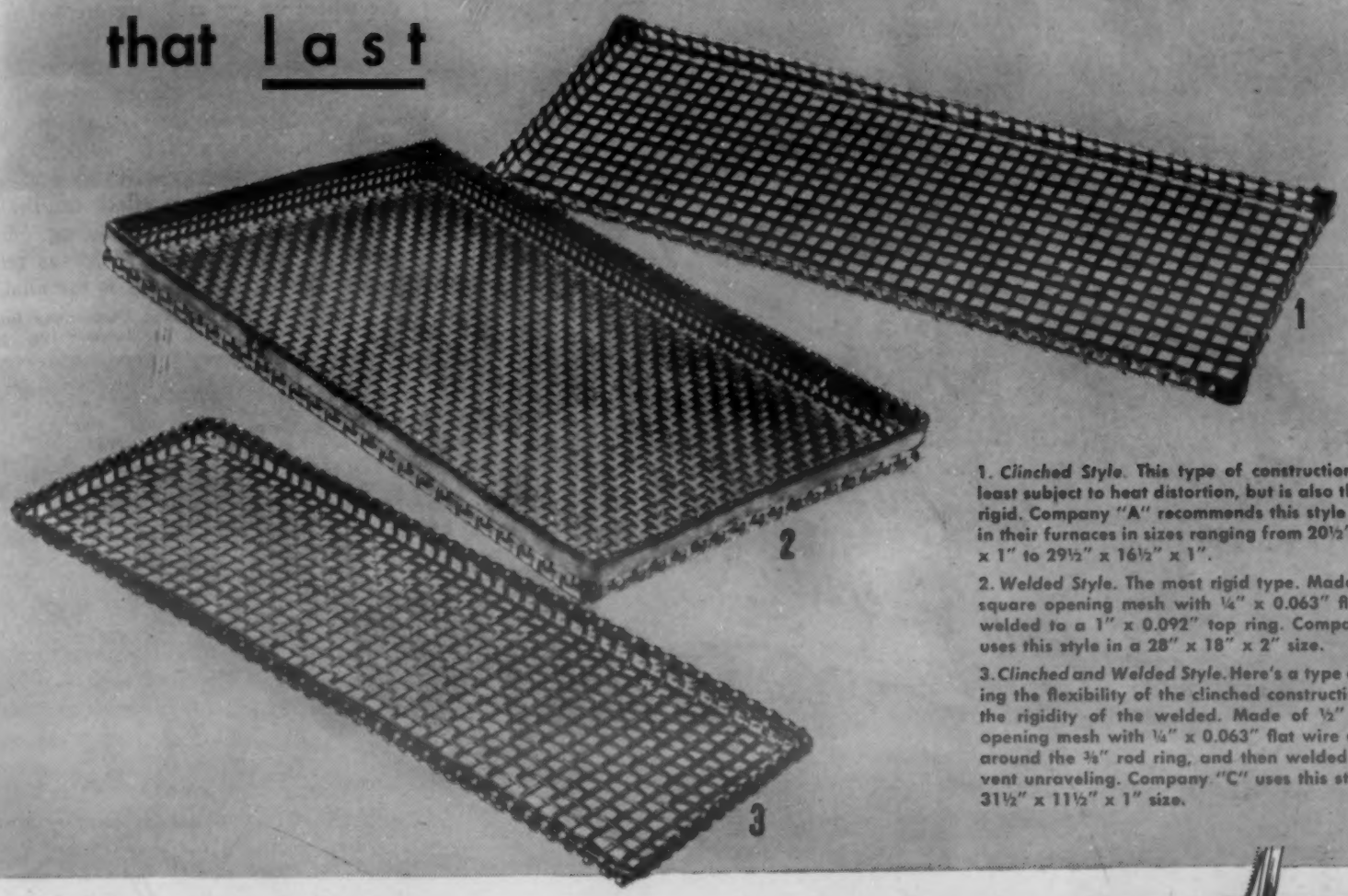
Up to 1935 there were only four manufacturers of thread grinders in the world. Shortly after that, there were 14, all of whom confine themselves to the single rib wheel, due to the difficulty of designing a satisfactory multi-rib dresser.

Now only two are capable of producing a multi-rib wheel, both being British inventions. One is the pantograph dresser working on the principle of an enlarged former plate contacted by a stylus actuating two

3 Ways to make

BRAZING TRAYS

that last



1. *Clinched Style.* This type of construction is the least subject to heat distortion, but is also the least rigid. Company "A" recommends this style for use in their furnaces in sizes ranging from 20½" x 6½" x 1" to 29½" x 16½" x 1".

2. *Welded Style.* The most rigid type. Made of ¼" square opening mesh with ¼" x 0.063" flat wire welded to a 1" x 0.092" top ring. Company "B" uses this style in a 28" x 18" x 2" size.

3. *Clinched and Welded Style.* Here's a type combining the flexibility of the clinched construction with the rigidity of the welded. Made of ½" square opening mesh with ¼" x 0.063" flat wire clinched around the ⅜" rod ring, and then welded to prevent unraveling. Company "C" uses this style in a 31½" x 11½" x 1" size.

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And, here you see how Inconel goes to work to make long-lived brazing trays that cut replacement and minimize operating interruptions.

The trays shown represent the three principal types of construction supplied to order by ROLOCK, INC. of Fairfield, Conn. Used at brazing temperatures of 2050° F., these all-Inconel trays have outlasted and out-performed other materials previously used. In fact, all through brazing equipment, you'll find parts being made of Inconel . . . to ensure long, trouble-free service.

For more information on the metal that fights high heat . . . oxidation . . . corrosion . . . mechanical abuse . . . write for your copy of *"For Long Life at High Temperatures."* The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

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sets of compound slides, connected by reducing linkage. The other is a cam design.

There is also a third method of the multi-rib crushing roller, but this is only an intermediate stage. It is always easier to produce an accurate product with a multi-rib wheel than with a single rib wheel.

The demand for accurate threads in the aircraft industry required a more rapid production. A freer cutting wheel was indicated and the age old method of forming the wheel by the crushing method returned with modern precision technique applied.

For the lubricant and coolant, neat oil should be applied for 90% of the work and wherever possible. It has a remarkable effect on crushing, and enables the roller to be fed into the wheel easily and without strain. The cleaning effect on the wheel prevents glazing and clogging. But on extremely accurate work, such as reference gages, soluble oil coolant is essential.

—M. Jellis & A. James. *Engineering Inspection*, Vol. 10, Summer 1945, pp. 4-14.

Nickel Flashing of Enamel Stock

Condensed from "The Journal of the American Ceramic Society"

A flash nickel coating is one method used to avoid dark colored cobalt enamels. Fluoride treated nickel plating baths have the advantages of cleanliness, crystal fineness, elimination of passivity and stabilization of pH value over normal sulphate baths.

The optimum amount of nickel varies with the type enamel; it is 0.05 g./sq. ft. for zircon enamels and 0.08 for antimony enamels. The nickel flash as applied to the steel is chiefly metallic nickel with small amounts of nickel hydroxide or nickel oxide.

The role of nickel in developing enamel adherence is apparently bound up with its retardation of the oxidation of the iron during the enameling and its effect on the nature of the iron oxides formed. Probably enamel adherence may be considered a corrosion phenomenon of the base iron developed by the action of the gases and other agents which may be present at the enameling temperatures. As such, the degree of adherence is a function of the oxygen pressure at the interface when the glass is fused.

The adherence promoting oxide on steel sheet appears to be FeO at the enameling temperature. At this temperature the FeO is formed under certain equilibrium conditions, which are obtained through the presence or formation of a material, probably a metal, taken from the group known as adherence promoters, which acts as a stabilizer for the continued development of FeO.

The bond at room temperature will consist of a mixture of the stabilizer material, probably metal, iron and Fe_3O_4; the latter two are the result of the decomposition of FeO on cooling. An alloy of iron and the stabilizer metal possibly may form the adherence promoters in the glass. For the adherence to be effective, certain equilibrium conditions must be met.

—E. Wainer & W. J. Baldwin. *J. Am. Ceramic Soc.*, Vol. 28, Nov. 1, 1945, pp. 317-326.

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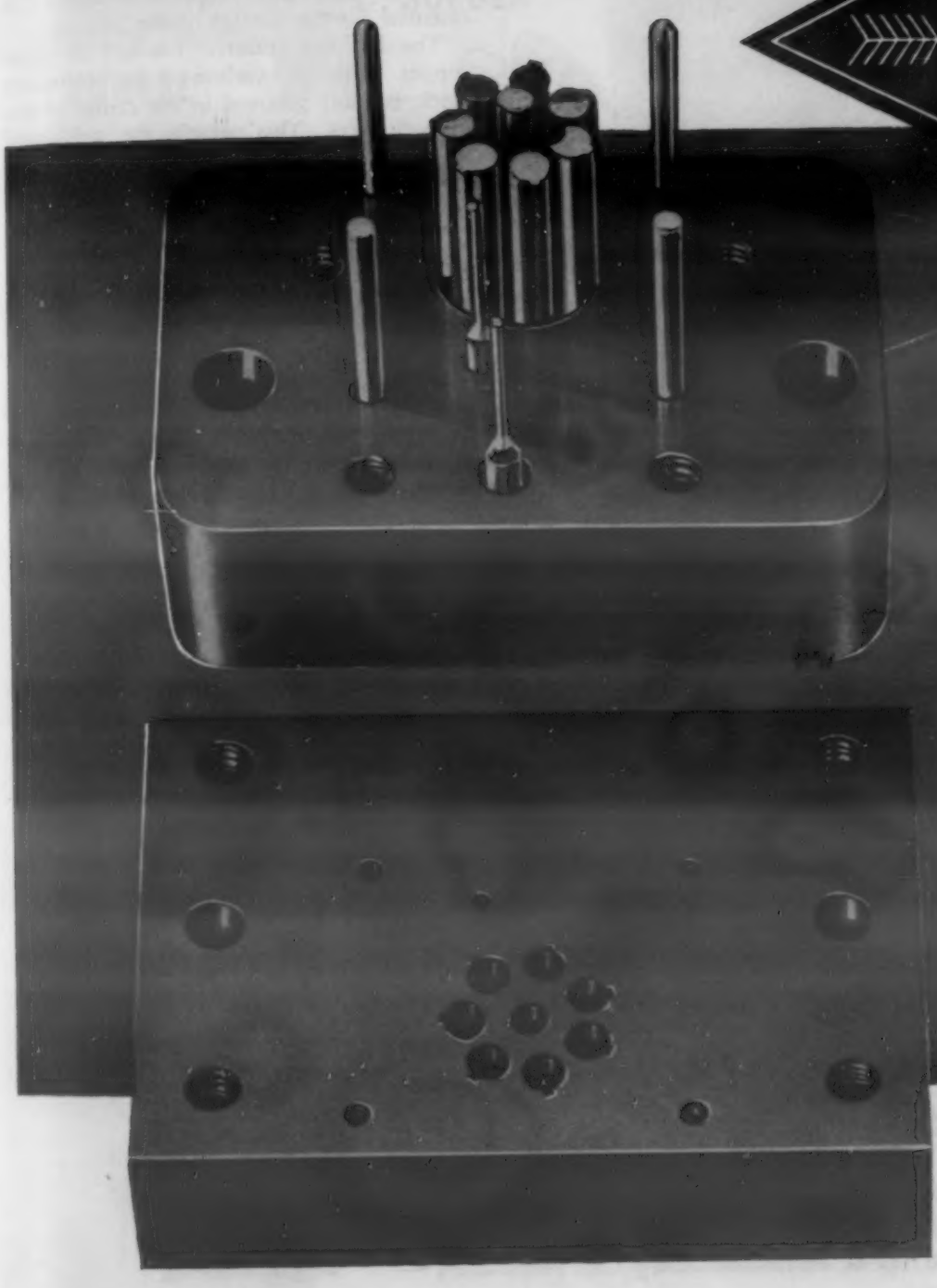

These Invaro oil-hardening steel blanking dies are meeting a difficult requirement of close tolerance—held to .003 after heat treating . . . no tendency to shrink, warp or change dimensions. Uniform hardness and long life mean high production at low cost.

Look into Invaro for operations such as blanking, punching, forming, piercing, perforating, etc.

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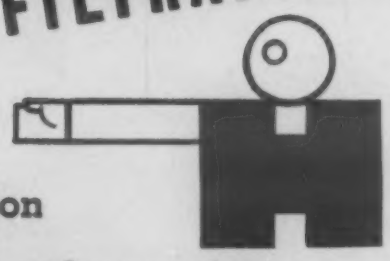

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Deep Penetration Welding

Condensed from "Transactions" of the Institute of Welding

High-speed, high-current butt welding of unprepared or semi-prepared steel plates is sometimes required.

Electrodes used are of the deep-penetrating, cup-forming type, $\frac{5}{16}$- and $\frac{3}{8}$-in. in diam. Bridges, cut "single" or "twin" from scrap and usually $\frac{1}{4}$- or $\frac{5}{16}$-in. thick, are tack-welded to the under side of the plates to be welded at approximately 9-in. centers, transversely to the direction of the seam.

Wedges are cut from scrap material, preferably $\frac{1}{2}$-in. thick, and are used with the bridges to obtain the necessary close contact between the backing set-up and the under side of the work. This close contact is essential for the success of the process.

The backing material consists of either copper strip or carbon-silicon refractory brick, suitably grooved in the center of one or both faces. This permits the weld-metal to penetrate to the under side of the work and gives the bead thus formed a neat and smooth appearance.

When copper is used for backing, it is in turn backed by an inch-square mild steel bar. This helps to dissipate heat but not too rapidly to give an unduly rapid quench. The steel bar is not required when refractory brick is used for backing.

The several component parts are finally set up so that the seam to be welded lies centrally within the groove of the backing material. The latter is tightly fitted to the under side of the parent plates by driving the wedges within the opening left between the steel bar and the bridges.

Current of 550 to 580 amp. is the minimum used for welding $\frac{5}{16}$ to $\frac{3}{4}$ in. plate, using a copper backing. If the current is too high the copper strip may be melted through. By elimination of "V" preparation in thicker plate, 750 to 900 amp. may be used. Greatly increased currents can be used with refractory brick as a backing. Correct speed of forward travel is important.

This procedure has been used extensively in a shipyard. Test results have shown that it is equally as effective as a weld made in the overhead position. It is economical in time, material and labor, and requires only simple equipment.

—B. W. Silverwood, *Trans. Inst. Welding*, Vol. 8, Aug. 1945, pp. 101-108.

Bright Dipping

Condensed from a Paper of the Electrochemical Society

For the final bright dip in bulk dipping of copper and its alloys there is recommended a solution of 800 gm. per l. sulphuric acid (sp. gr. 1.84), 100 gm. per l. nitric acid (sp. gr. 1.38), 2.5 gm. per l. hydrochloric acid (sp. gr. 1.17), and 491 gm. per l. water at a maximum of 95 F.

A typical composition for a "scaling" dip is 700 gm. per l. concentrated sulphuric acid, 100 gm. per l. concentrated nitric

(Continued on page 240)

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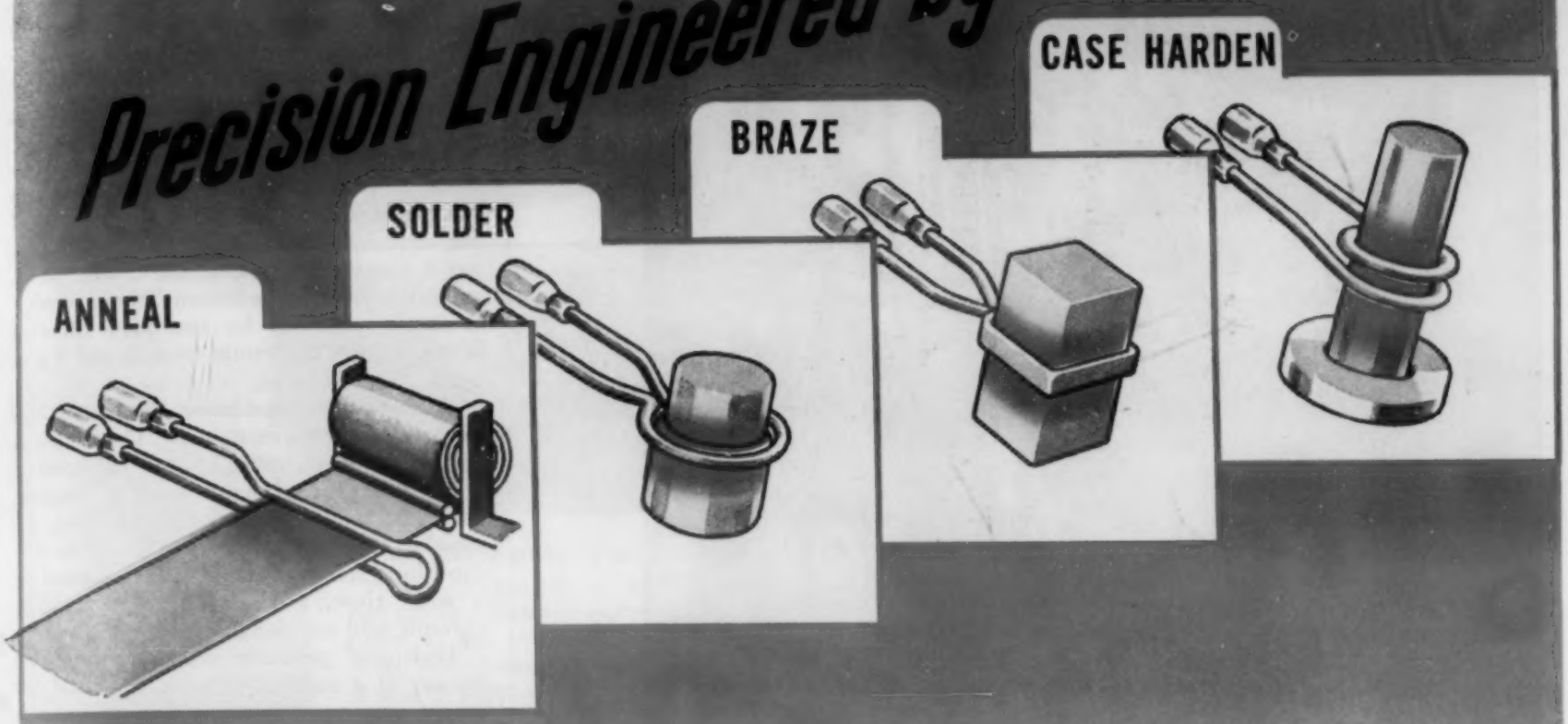

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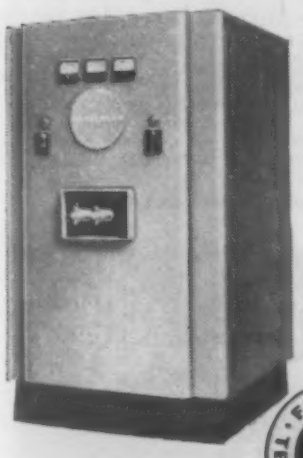

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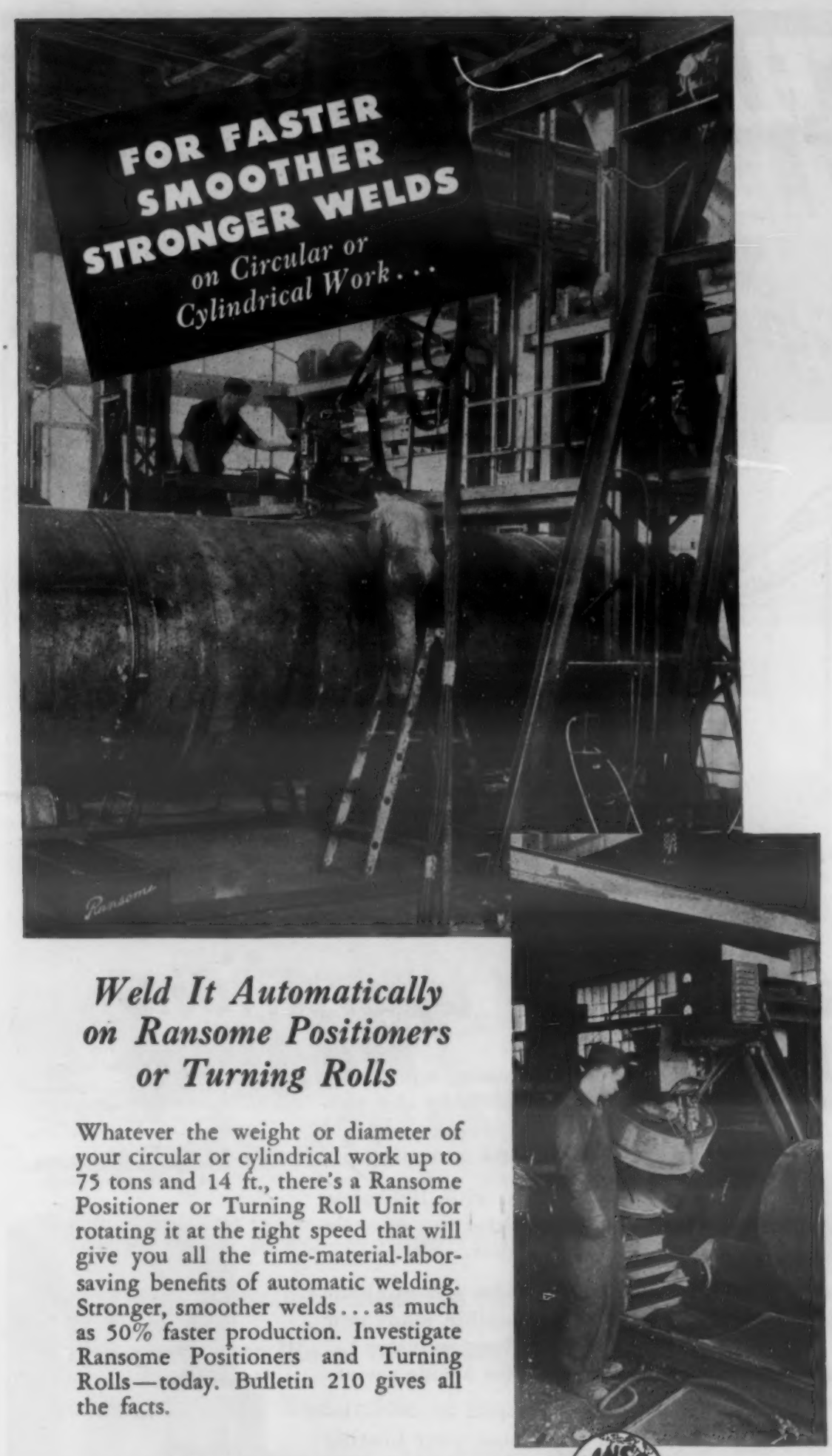

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acid, 5 gm. per l. concentrated hydrochloric acid, and 544 gm. per l. water.

To overcome discoloration in automatic handling, a proposed bath contains 50% sulphuric acid, 36% nitric acid, and 14% phosphoric acid. To inhibit evolution of nitrous gases, reduce the reaction rate, and passivate the metal, a solution is used which contains 80 cc. sulphuric acid, 20 cc. nitric acid, 1 cc. hydrochloric acid, 55-60 gm. chromium trioxide, and 200 cc. water.

Weak solutions of nitric acid have been proposed as bright dips for cadmium and zinc plate, as well as chromic acid solutions with a small amount of sulphuric, hydrochloric, or nitric acids, but after-treatment may be required.

Preferred solutions, not requiring after-treatment, are: 100 gm. per l. chromium trioxide and 1.67 gm. per l. sulphuric acid for cadmium "rack work"; and 100 gm. per l. chromium trioxide and 1 gm. per l. sulphuric acid for cadmium "barrel work." A suitable solution for zinc plate contains 300 gm. per l. chromium trioxide and 5 gm. per l. sulphuric acid.

Another recommendation for zinc is 200 gm. per l. chromium trioxide, 15 gm. per l. sodium sulphate, and 52.5 gm. per l. nitric acid. For zinc alloys containing copper, there is used a solution containing by weight, 25% chromium trioxide, 10% hydrochloric acid, and 65% water, followed by a water rinse, and immersion in a 10% chromic acid solution.

Hydrogen peroxide solutions, acidified by any of a number of acids, are used for bright dipping of cadmium and zinc plates. Preferred solutions are: for cadmium, 7% by volume of 30% hydrogen peroxide with 0.3% by volume sulphuric acid (sp. gr. 1.84); for zinc, 4% by weight hydrogen peroxide and 0.25% by weight sulphuric acid.

Oxyacids of the pentavalent halogens, especially 0.1-0.76 N bromic acid, brighten cadmium.

Some solutions used for cadmium and zinc may be suitable for magnesium. An aqueous solution containing 3.5% by volume of 30% hydrogen peroxide and slightly less than 3.5% by volume of glacial acetic acid may give a satisfactory bright dip on lead.

Bright dips have both brightening and smoothing effects. It is probable that fundamentally the same or similar electrochemical phenomena take place in bright dipping as in anodic brightening.

—Gustaf Soderberg. *Electrochemical Soc.*, Preprint No. 88-10, Oct. 1945, 6 pp.

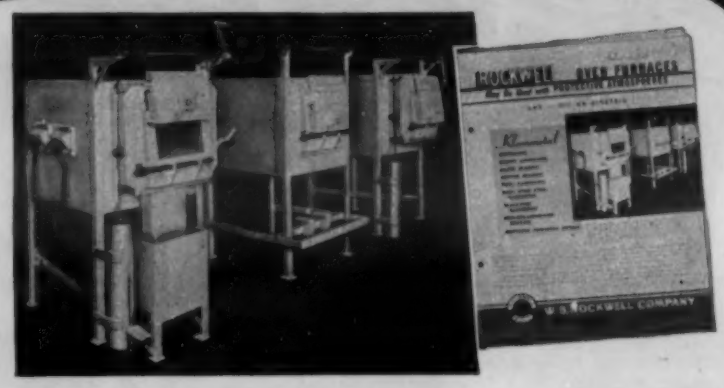
Welding Wire by Powder Metallurgy

Condensed from "The Welding Journal"

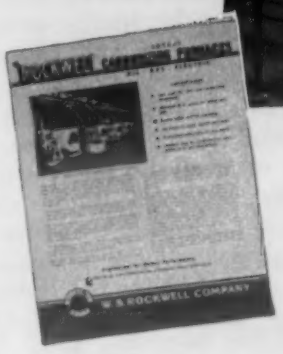
Realizing the need in the special alloy welding rod field for wire alloyed of elements difficult to produce by normal rolling and drawing, and the need for cheaper methods of producing stainless steel welding wire, Associated Industrial Engineers, Inc., Philadelphia, developed a method of producing through powder metallurgy a rod with any desired analysis.

The finished synthetic welding wire is a small diameter base wire encased within a

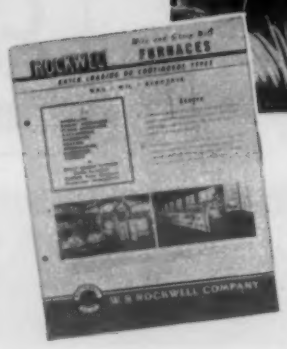
You'll Want to Refer to These FURNACE FACTS on More Efficient HEAT TREATING



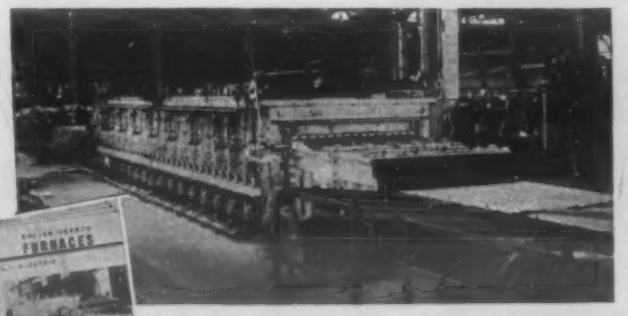
KLEENMETAL HEATING—Batch type, gas, oil or electric; direct heated or muffle furnaces, with cooling chambers or enclosed quench chutes for use with or without protective atmospheres, in clean or bright annealing, scale-free hardening, brazing or sintering powdered metals—temperatures to 2400°F. Bulletin No. 417.



ROTARY CARBURIZING—Six standard units—oil, gas or electric—for small pieces that can be tumbled in carburizing compound or gas atmosphere in an alloy retort. Reduce handling costs—no boxes to pack or heat. May be used for other heat treating in any controlled atmosphere. Bulletin No. 412.



WIRE OR STRIP HEATING—Continuous or batch annealing or bright annealing, hardening, normalizing or patenting of ferrous or non-ferrous metals from cakes, bars or billets to the finest wire, with the best methods of handling, heating, cooling or quenching. Bulletin No. 418.



CONTINUOUS HEAT TREATING—Roller hearth furnaces for faster, more uniform heat treatment of forgings, castings, bars, plates, tubes, stampings, structural shapes, etc., with control of heating and cooling rate and attendant operations. Bulletin No. 419.

LOW TEMPERATURE HEATING—Ageing, annealing, drawing, normalizing, preheating or stress relief to 1200°F. in batches on trucks or cars, intermittent or continuous conveyor ovens. Catalog No. 115.

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cladding of powdered metals. The base wire is made of that element comprising the major constituent of the finished weld deposit, with a second coating of welding flux dipped or extruded over it.

In making synthetic 19/9 (Type 307) grade of welding wire, a base wire of ingot iron (0.03% carbon) is clad with sufficient powdered low-carbon ferrochrome, pure nickel, ferromanganese and ferrosilicon to combine under the welding arc with the ingot base wire to produce a weld deposit of standard Type 307 stainless steel. The maximum chromium nickel content so far achieved, without exceeding a workable finished diameter, has been the 25/20 grade of heat-resistant alloy.

The density may be varied from 50% of drawn steel density to 85% of drawn steel density by varying the pressure exerted on the powdered metal compact around the base wire. One can also vary the quantity of filler used to fill in the voids between the powdered metal particles.

After much experiment it was found that metal powders, if properly selected for particle size and mixed with suitable filler and bonding material, can be readily extruded much the same as welding rod fluxes are now extruded on drawn welding wire.

It was found that thorough sintering was not necessary and the wire required just sufficient bond to give the wire strength and durability to withstand normal abuse. The baking and hardening treatment required a controlled hydrogen atmosphere. There are needed special dies and hydraulic presses built for pressures up to 18,000 p.s.i., though 9,000 p.s.i. has been satisfactory.

—F. G. Daveler & P. H. Aspen. *Welding J.*, Vol. 24, Sept. 1945, pp. 842-844.

Basic Electric Steel Making

Condensed from "General Electric Review"

The carbon in the charge for basic electric steel should be such that after a 30 to 40 min. boil, its concentration is equal to or only slightly below the desired final content. A deficiency is best made up with low-silicon, high-carbon pig iron.

Iron ore is added to the charge, and later in the process, to provide oxygen which reacts with carbon to produce the boil. The best plan is to include in the charge only sufficient ore for oxidation of silicon and manganese and to add the rest as melting proceeds. Lime is added to the charge, and during and after melting, to maintain a lime-silica ratio of about 3 to 1. It is well to keep silicon and manganese in the charge low.

The melt-down should be started with low voltage and a short arc to protect the roof from excessive heat. As soon as the electrodes have burrowed a short distance into the charge, the voltage may be raised.

The carbon monoxide bubbling from the bath during the boil carries with it hydrogen, nitrogen, and other dissolved gases. Apparently this is the only method of eliminating them. The boil should be vigorous and should begin shortly after melting is complete. A boil of 30 to 40 min. may be considered ample.

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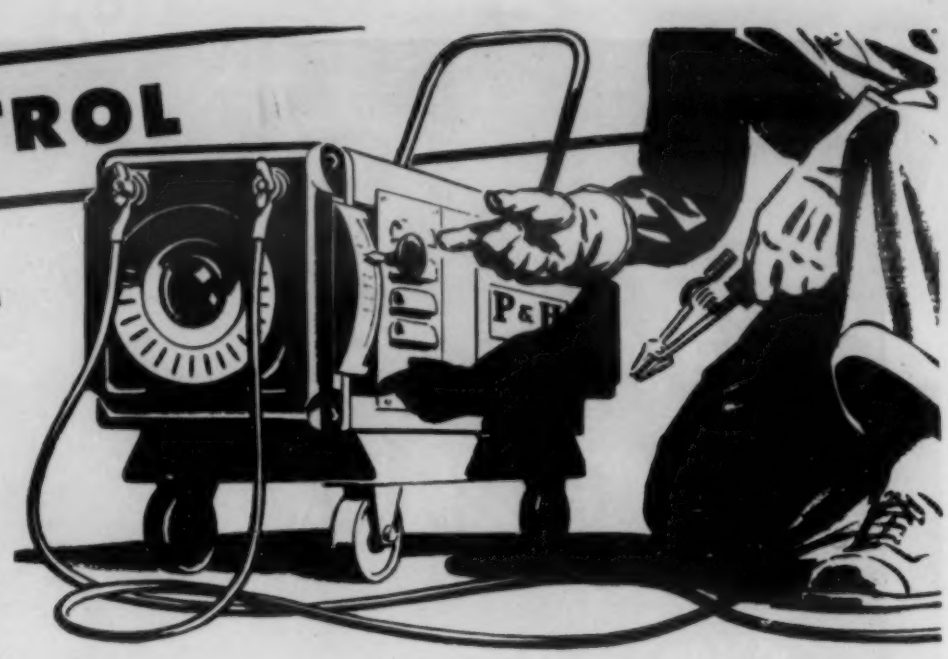

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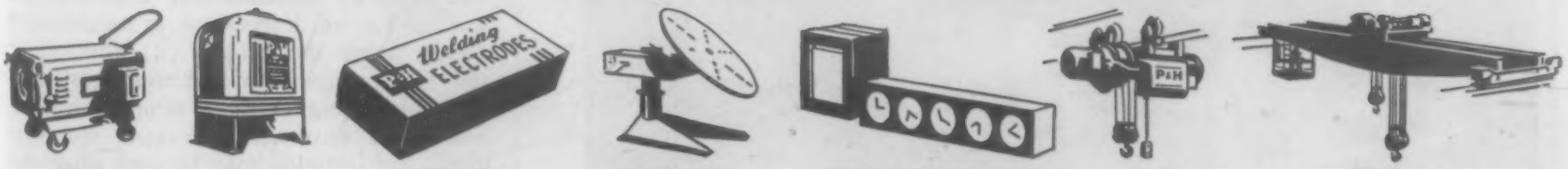

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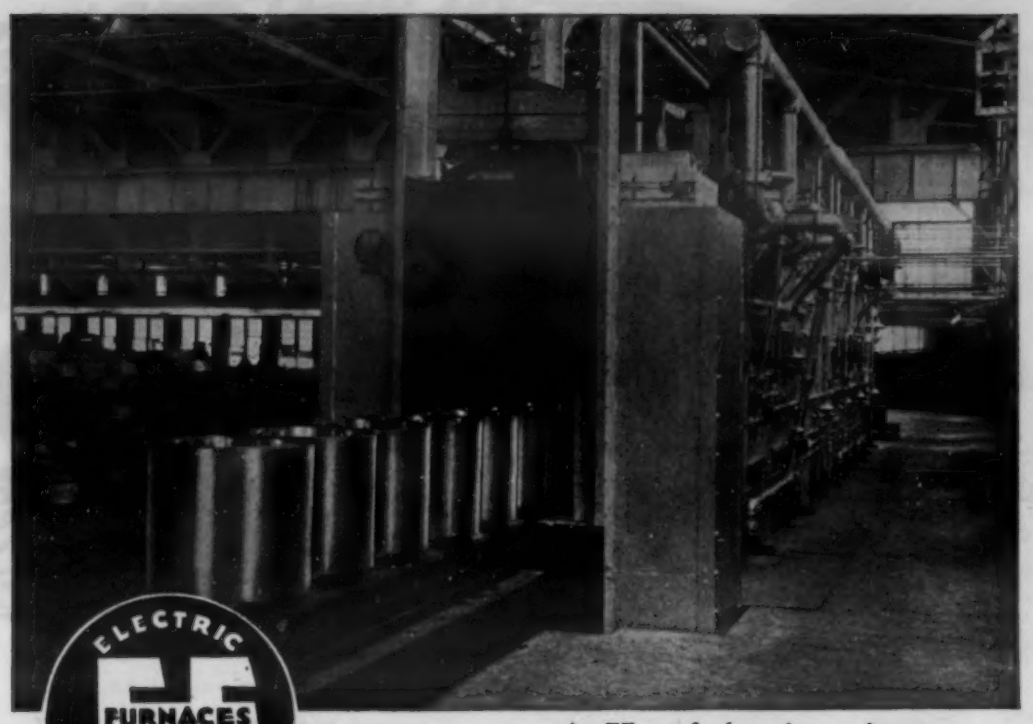

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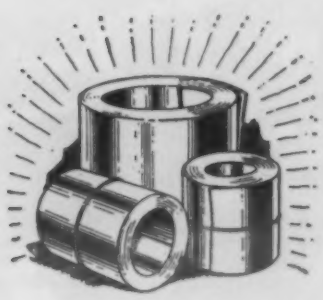

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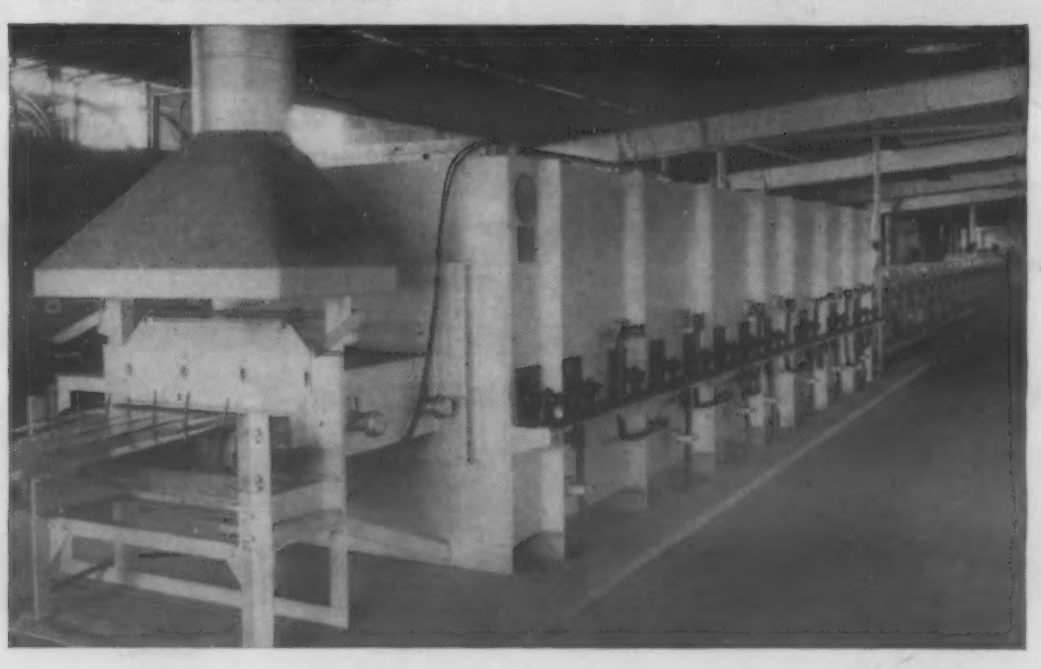

When the boil has been stopped, a calcium carbide slag is formed which immediately starts deoxidizing the bath. As soon as deoxidation by the slag is finished, final adjustments in composition are made and the heat tapped.

Hydrogen in steel is deleterious. The principal source is moisture, which is likely to be found in the lime, iron ore, furnace bottom, slag material, etc. Therefore, care should be taken that all materials added to the furnace, particularly after the boil, are moisture free.

In standard practice, reabsorption of gases can begin at the end of the boil. As this is undesirable, it is advisable to tap the heat before the gases have a chance to be reabsorbed. This can be done by eliminating the reducing period and tapping the heat within a few minutes after killing the boil. These few minutes are sufficient for the addition of ferromanganese. Final silicon addition would then be made in the ladle.

Heats made this way have shown that this procedure offers promise.

Advantages expected are: less gas in the metal when it goes into the ladle; less nitrogen to inhibit grain growth; time from pouring to charging is reduced; less power consumption; and longer life of refractory.

Disadvantages are: The steel may contain more inclusions and will be no lower in sulphur and phosphorus than that made by standard practice; and no delays can be permitted in handling the metal once it is ready to tap.

—M. V. Healy. *Gen. Elec. Rev.*, Vol. 48, Nov. 1945, pp. 55-57.

Refrigerating Aluminum

Condensed from "Modern Metals"

Most of the wrought aluminum used during the last four years has been of the heat-treatable variety, A 17 S, 17 S, and 24 S, the last two having the characteristic of changing materially in strength and workability on standing at ordinary room temperatures after they have been heat treated.

Natural age hardening is substantially completed after 4 days storage at room temperatures. The increase in strength is accompanied by a marked decrease in workability.

The use of refrigeration to delay the natural age hardening of this group of alloys has greatly speeded production, reduced fabricating costs and eliminated inconvenient fabricating practices. It does not alter the properties of the alloys but merely delays the natural aging process pending work on it, such as riveting. After fabrication the natural age hardening sets in and gives the aluminum alloy desired qualities.

The complete cycle of heat treatment consists of: (1) Solution heat treatment, or heating for an interval at a temperature slightly below the solidus; (2) quenching; and (3) precipitation heat treatment, consisting of aging at room temperatures or heating at moderately elevated temperatures. Refrigeration may be used after the second step.

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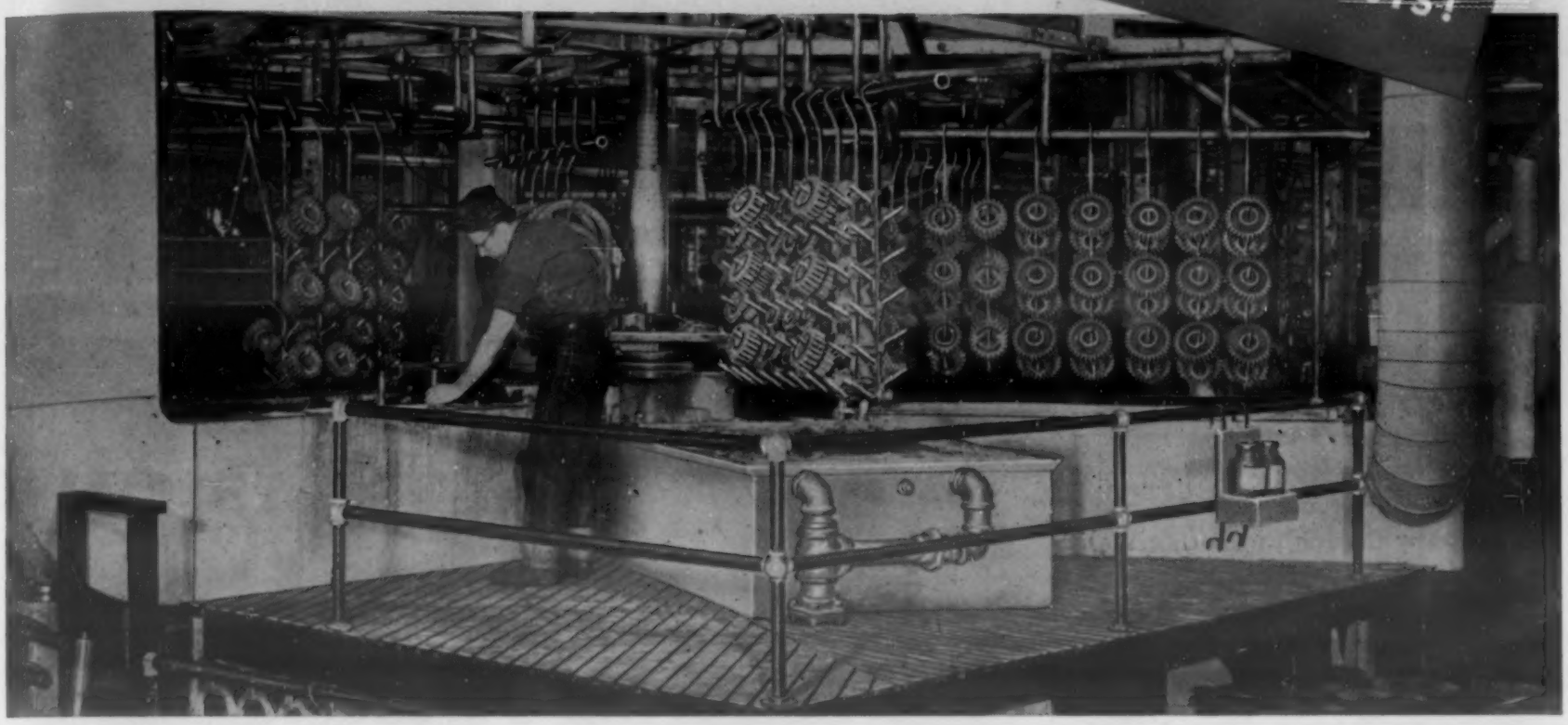

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Natural age hardening of 17 S alloy is retarded 24 hr. if stored at 32 F, and for an indefinite period when stored at –40 to –100 F. All parts should be chilled as quickly as possible to the storage temperature decided on.

Sometimes refrigerated quenching media are advantageous. Usually a storage temperature of 0 F is satisfactory for 17 S and 24 S. Temperatures as low as –40 F and lower have been used for a greater margin of safety.

At extreme temperatures the parts usually stick together, in which case an alcohol rinse after quenching will minimize frosting, or the parts may be stored in alcohol or kerosene.

If storage temperatures much below 0 F are used, the unit must be capable of maintaining the chosen temperatures even under working conditions, such as frequent withdrawal of stored parts and carelessly leaving the storage door open.

For distribution to remote parts of the plant, various portable refrigeration units must be used, operated either mechanically or by dry ice. The latter has proved popular because of low temperature provided, simplicity and relatively low cost.

—M. L. Rask. *Mod. Metals*, Vol. 1. Oct. 1945, pp. 19-21.

Pickling with Submerged Combustion

Condensed from "Wire and Wire Products"

Submerged combustion was developed by Brunler in 1887. Automatic ignition was applied in 1930 by the Submerged Combustion Co. but not sold commercially until 1937.

Controlled by a mercury switch, present day burners are a nozzle mixing type, using an air-gas ratio giving maximum combustion efficiency. The hot combustion products are passed through a tubular chamber to the bottom of the tub, where they are vented and distributed to give the desired rate of agitation.

When the solution reaches the correct temperature, the thermostat shuts off the gas flow but not the air, so that the fixed rate of agitation is maintained. Solution temperatures may be controlled to within 3 to 5 F, and are maintained at 170 F.

The CO_2 in the combustion products aids in removing the lime on fine steel wire when pickled by this method. Also, repickles are reduced, amounting to savings up to 10% of total pickling tonnage.

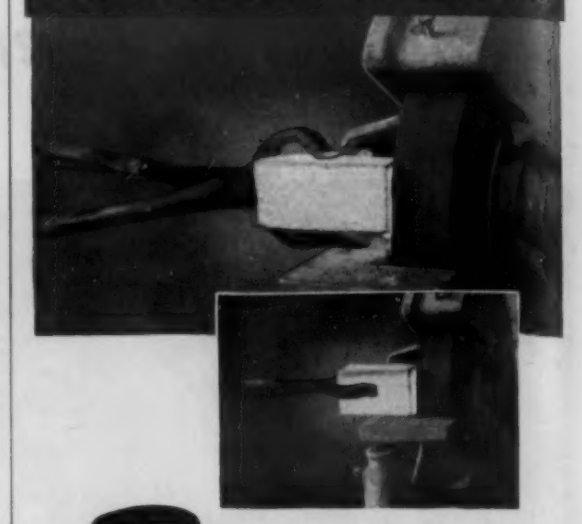
Maintenance costs per burner in one installation has been $70.93 a year for parts. In all, there are approximately 80 units in operation throughout this country and the United Kingdom.

Principal advantages of this method of pickling are a more uniform cleaning of better quality because of extreme agitation and controlled temperature, reduced acid costs, faster cleaning and thereby lower labor handling costs, lower heating costs.

It is possible to pickle one ton of steel rods using 100 cu. ft. of 1000 B.t.u. gas.

—H. N. Snowden. *Wire & Wire Products*, Vol. 20, Oct. 1945, pp. 750-751.

BRICKSEAL
REFRACTORY COATING

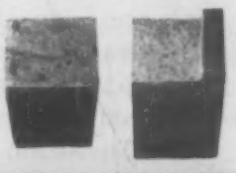


Resists
ABRASION

PROTECTION against abrasion is an outstanding advantage of Brickseal. Here are two refractory bricks, one coated with Brickseal, the other uncoated. They were heated to more than 2000°, taken directly from the furnace and shoved against an emery wheel. Hot and cold, the Brickseal-treated brick resisted the abrasion – see below.

Brickseal consists of high fusion clays and metal oxides combined in oil. Furnace heat burns away the oils and vitrifies the clays and metals which penetrate deeply into the pores, cracks and joints. Brickseal prevents cracking, spalling and slagging regardless of sudden temperature changes. Brickseal is also a mortar for laying up refractory walls.

Compare the Brickseal-treated brick at the left to the untreated at the right.

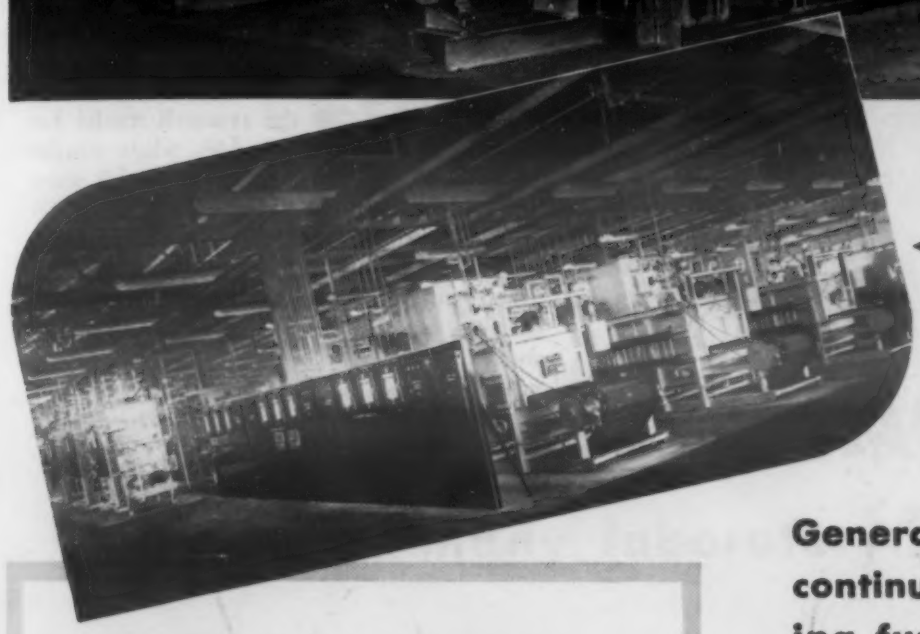


TRY IT YOURSELF
on your
emery wheel

Two bricks bonded together and partially coated with Brickseal will be mailed to you on request.

BRICKSEAL
REFRACTORY COATING
5800 So. Hoover St., Los Angeles, Calif.
1029 Clinton St., Hoboken, New Jersey

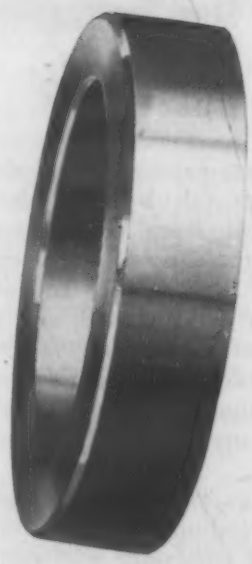
Atmosphere Hardening



View showing charge end of hardening furnace units equipped with magnetic vibrator charging mechanisms. Note 3 RX Gas Generating Units in foreground at right.

View showing 3 RX Gas Generating units, Control Panel and discharge end of recirculating-air draw-furnaces.

Thousands of small parts are clean and bright hardened in this modern heat-treating department. RX Gas Generating units supply atmospheres to three continuous-type, radiant-tube heated hardening furnaces. The pieces are automatically quenched and drawn to complete the heat-treating operation.



CLEAN AND BRIGHT... METALLURGICALLY RIGHT!

Bearing races treated in the above furnaces are made of 52100 steel which is inherently difficult to harden without decarburization.

After RX Gas Atmosphere Hardening these races are clean and show a uniformly hardened surface. Rockwell C 64-66.

Of importance is the close control of carbon balance between the metal and the RX Gas Atmosphere during the hardening operation. Not only are the processed parts clean and bright in the finished form but metallurgically the individual pieces are practically unchanged in carbon percentage—there having been no transfer of carbon between the metal and the atmosphere.

'Surface' research in the Science of Gas Chemistry and Heat Treating has made possible this significant advancement in metals processing. 'Surface' bulletins are available on the application of atmospheres to practically every heat treating operation. Write, stating your particular interest.

* **SPECIAL ATMOSPHERE, RADIANT-TUBE FURNACES FOR:** Gas Carburizing and Carbon Restoration (Skin Recovery), Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing, Atmosphere Forging, and Specific Effects upon Metal Surfaces.

'Surface'

SURFACE COMBUSTION CORPORATION · TOLEDO 1, OHIO

METHODS AND PROCESSES

TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards and quality control.

Coating Thickness Gage

Condensed from "The Monthly Review" of the American Electroplaters' Society

At the present time, there are two instruments in wide use for the determination of local thickness of coatings by magnetic means. The Brenner Magne-Gage employs a sensitive spring balance to measure the force required to withdraw a permanent magnet from the coated steel surface. The other instrument is an electromagnetic device manufactured by the General Electric Co., which measures coating thickness by the amount the flux of a magnetic circuit is reduced by the coating, when it comes between the pole pieces of the core and the steel basis metal.

The development of an alternate instrument for measuring non-magnetic coatings on steel has been announced at Frankfort Arsenal. This instrument requires a source of alternating current which is used to energize a solenoid containing a movable iron core.

If the core is withdrawn from the field of the solenoid, the magnetic pull on the core increases. Therefore, if the energized solenoid is held vertically over a coated steel article and lowered so that the lower end of the core contacts the surface, the distance through which it may be raised for the pull of the solenoid to overcome the attraction of the core for the basis metal will vary inversely with the thickness of the coating.

The reproducibility of the instrument was determined by taking 100 readings at a single spot on a thickness standard. The results indicate that the research model has a maximum error of ± 4%, while similar tests conducted on the service model show a maximum error of ± 5% in the 0.0002-in. range, and ± 3% in the 0.002-in. range. It is believed that this reproducibility is greater than the usual uniformity of the coating, especially in the lower ranges, and should therefore be adequate for most practical uses.

—S. Lipson. *Monthly Rev.*, Am. Electroplaters' Soc., Vol. 32, Sept. 1945, pp. 888-889, 936.

Factor Method for Steel Hardenability

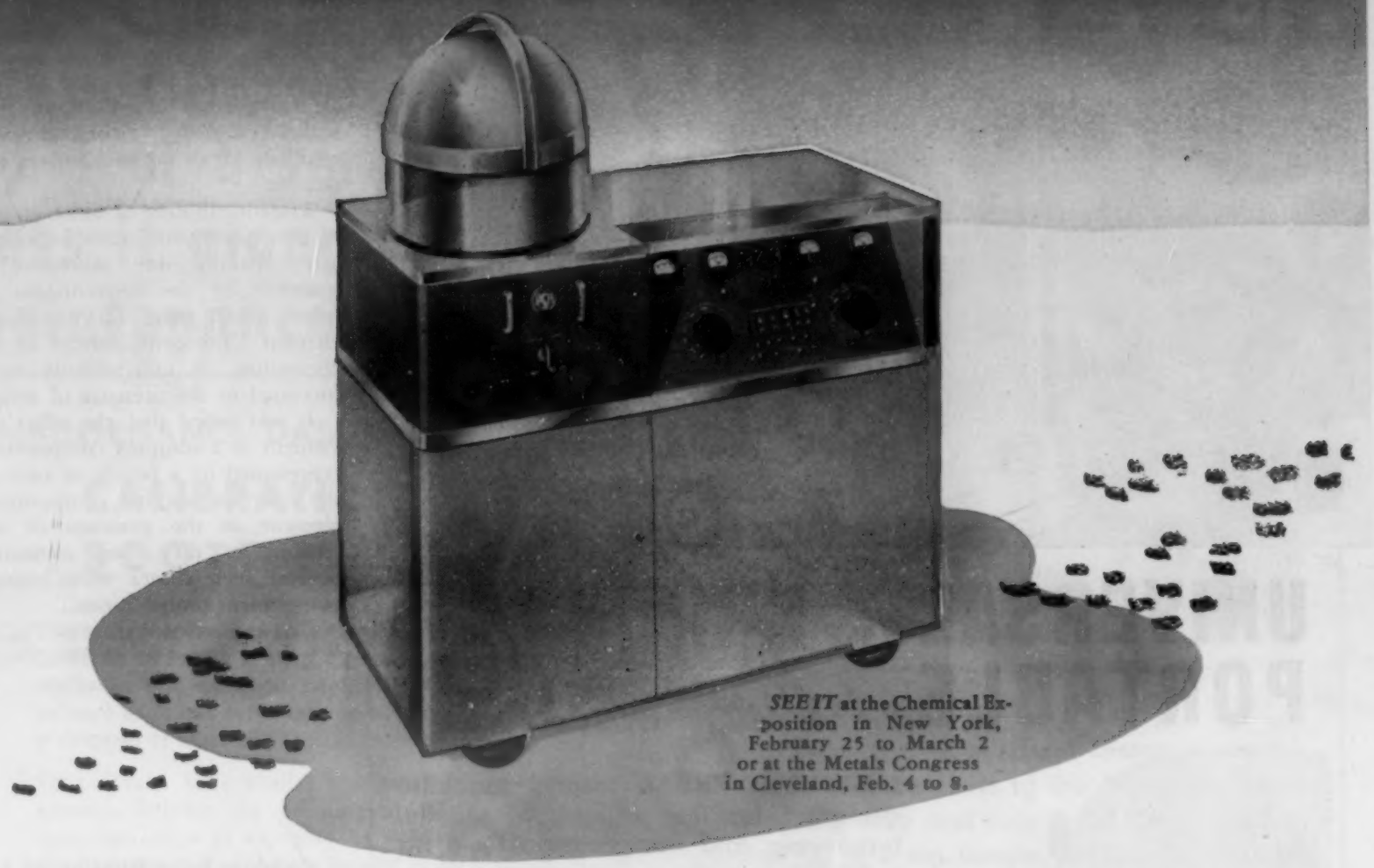
Condensed from a Paper of the American Institute of Mining & Metallurgical Engineers

Opinions have been expressed that the Grossman method for calculating hardenability of alloy steels from composition over-simplifies the problem. A non-linear relationship between hardenability and alloy content has been demonstrated, and it has been shown that Grossman's factors undervaluate the hardening effect of low percentages of chromium, silicon, manganese, and nickel, and overvaluate the larger additions.

To determine by experimental methods actual hardenability relationships, steel bars were made up in the laboratory with carefully controlled compositions, hardenability was determined by the Jominy method, and results studied. It was found that the factor method gave results that were, in general, too high for steels containing rather large percentages of a single alloying element. They held fairly well for plain carbon steels and steels of simple composition.

In each case where the actions of two elements in substantial amounts were studied, the observed critical diameters were greater than those calculated by multiplying the determined single element quantity

A VERSATILE VACUUM!



SEE IT at the Chemical Exposition in New York, February 25 to March 2 or at the Metals Congress in Cleveland, Feb. 4 to 8.

NEW RCA VACUUM UNIT

speeds many laboratory and factory processes

Here are a few of the jobs that this new, multi-purpose RCA vacuum unit will help you do easier, quicker, and better: Mirror making; lens coating; vacuum or freeze drying; evaporating, condensing, or sputtering of materials on metal or non-metallic surfaces; and experiments where various gases at reduced pressures are required.

The RCA vacuum unit (Type EMV) consists of a vacuum chamber or bell jar, a high-speed pumping system (with simplified valving) to evacuate it, a control system, and meters and gages for reading currents, voltages, and vacuum pressures.

Within the bell jar are nine pairs of terminals.

Six of these are each capable of carrying 50 amperes. They are used to light filaments for the evaporation of metals or other materials. Any number up to six filaments can be used, and connected in series or parallel from outside the vacuum chamber. The power available for these circuits is 5 kva.

Another set of terminals is capable of carrying up to 5000 volts at 80 milliamperes—useful for ionization cleaning and for sputtering metals.

The two remaining pairs of terminals are useful in making measurements in the vacuum chamber while it is being pumped out, and for supplying power to heaters or other equipment within the bell jar.

Provision has been made so that gases, if desired, can be admitted into the vacuum chamber after the air is removed.

This vacuum unit comes equipped with two bell jars: one 18 by 18 inches, the other 18 by 29 inches (height). A vacuum of better than ½ micron (mercury) pressure is rapidly achieved in 7 or 10 minutes depending upon the size of the vacuum chamber used.

A new bulletin is now available describing many of the other features of this device which contribute to its safe, quiet, easy operation. Ask for your copy today. Write: Radio Corporation of America, Dept. 52A, Engineering Products Division, Camden, N. J.

RCA

SCIENTIFIC INSTRUMENTS

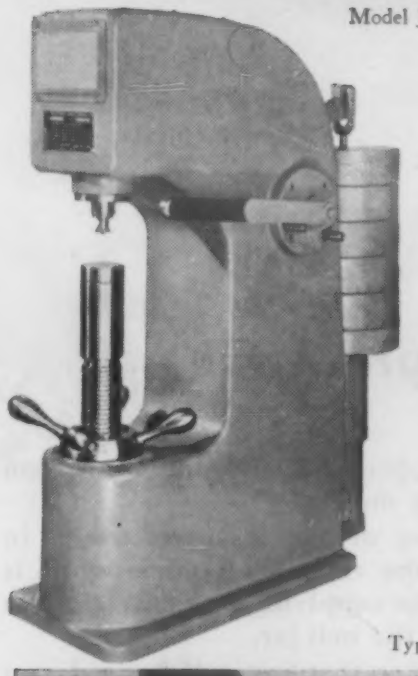
RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.

MP-10

UNIVERSAL • BRINELL • PORTABLE *testing machines*

Model J



Type "P"

MP-10 UNIVERSAL testing machine designed for the making of tensile, transverse and compression tests up to 60,000 pounds, is hydraulicly operated. . . . A maximum stroke of six inches is provided in the cylinder . . . the transverse table has a maximum span of thirty inches. . . . Illustration shows machine set up for tensile test. . . . MODEL J BRINELL testing machine of the manually operated bench type for the hardness checking of metals, is particularly designed to meet the requirement of the smaller shops, heat treat plants, laboratories, schools, etc. The Multi-Beam and Dead Weight principle is employed, with weights accurately calibrated for loads of 500 kgs. to 3,000 kgs. . . . TYPE "P" PORTABLE Hardness Testing Hammer makes practical the taking of tests right where the material is, in the shop, yard . . . on the truck, car . . . anywhere it may be, instead of taking the specimen to the testing machine. . . . There are other standard models and special purpose machines are also built to specifications.

Send for catalog and complete information outlining your testing requirements.

At the Metals Show . . . space B-720 . . . February 4th through 8th.

STEEL CITY TESTING LABORATORY

8843 Livernois Detroit 4, Michigan

factors. This situation is probably exaggerated when three or more principal alloying elements are combined.

Using the factors to check variations in percentage of a single element in a complex steel, it was shown that erroneously high values resulted.

In complex steels it was found that the hardenability contribution to composition for manganese, chromium, molybdenum, or nickel is a sharply rising curve. The hardenability factor of each increases with the content.

The contribution of nickel in the presence of chromium, manganese, or molybdenum, after making due allowance for their presence by the conventional factors, is much greater than for nickel as a single element. The contributions of manganese, chromium, or molybdenum are similarly increased in the presence of nickel.

It was found that the effect of any one element in a complex composition must be represented by a family of curves, showing the effect of varying compositions of that element in the presence of each given amount of the other elements present. Several such curves were constructed for two-element compositions.

—G. R. Brophy & A. J. Miller. *Am. Inst. Mining Met. Engrs.*, Tech. Pub. No. 1933, Oct. 1945. 10 pp.

Sulphur Print Studies of Fatigue

Condensed from a Paper of the American Society for Testing Materials

The sulphur print method was used to study crack distribution and rate of crack growth in SAE X4130 specimens that had been subjected to corrosion fatigue. The specimens were washed, soaked in concentrated hydrochloric acid for 30 to 40 min. to open up the cracks, washed, dried, soaked in a solution of 1 part of $Na_2S.9H_2O$ to 2 parts of distilled water for 45 min., and dried.

A small piece of photographic printing paper, soaked in tap water for 15 min., was then carefully wrapped around the specimen, pressed firmly into place, removed, fixed in hypo, washed, ferro-typed, and dried.

The corrosion products and iron sulphide probably fill the cracks and help retain sodium sulphide, which gives an insoluble dark precipitate of silver sulphide in the photo-sensitive gelatine when contact occurs. The resulting sulphur print is a permanent record of the crack pattern.

A series of sulphur prints was made at successively greater radial depths on damaged and failed specimens. This information enabled the determination of crack profiles and the rate of crack penetration. Corrosion fatigue cracks assume a wide variety of shapes and depths of penetration.

At high stresses, the range of depths of the deepest five to ten cracks increases with time. The higher the stress, the higher the rate of increase of slope. At the lower stress levels, the results are more erratic, due to the relatively larger influence of corrosion.

—R. C. Brumfield. *Am. Soc. Testing Materials*, Preprint No. 28, 10 pp.

If you own a Scott Tester, CUT OUT THIS DATA SHEET, No. 1 of a series, and pass it along to your maintenance man.

MAINTENANCE DATA SHEET NO. 1

CALIBRATION OF SCOTT TESTERS

The recording head of an inclinable balance Scott Tester is in reality a weighing scale. However, it works in one direction only, so that it cannot balance back and settle into position if the weight is dropped or otherwise applied too abruptly.

To calibrate, have available a weight of known amount. Balance the machine by allowing the pendulum lever to swing to its normal position, dead center, and adjust the pointer to zero on the dial. Attach the known weight to the upper clamp, which is connected to the chain of the recording head. (In computing the amount of the known weight, include the weight of all apparatus used to attach it.)

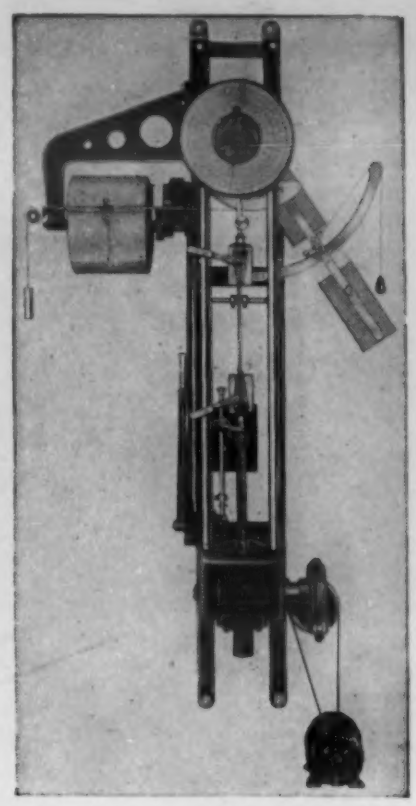
Allow the weight to exert its force by lowering gradually by hand. Do not drop it, but do not lower too slowly. Use the speed at which stress is applied in an actual test. The pointer should register upon the dial the exact amount of the known weight plus the attaching apparatus.

The pawls must be in the same position on the quadrant racks as in actual testing. The weight must be attached without binding or friction that would prevent the full force registering on the dial. The weight may be a pail of water, a bolt of cloth, a roll of paper, sash weights, etc. Whatever the weight, it MUST be accurately weighed.

Every Scott Tester is fully tested and calibrated at the factory, therefore, it is safe to assume that accuracy at any one point of the dial indicates a correct machine at all points.

Model J

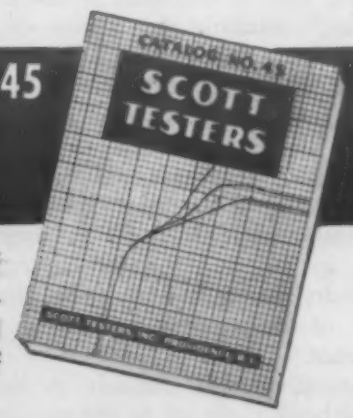
For determining tensile strength, elongation and yield point of extremely low elongation materials. Available in various double capacities with ranges from 0-50 to 0-1000 lbs.



The many models of *Scott Testers serve the varying requirements of the Metals Industry for testing wire and strip from finest filament wires up to 1 ton tensile, for tensile, elongation, hysteresis, twist, flexing, compression cutting of rubber covering, etc. The exclusive Incline-plane Tester is especially applicable to the finer sizes. Results are produced in the form of picturized charts, easily read without computation, and handy for filing as historical records.

* REGISTERED TRADEMARK

NEW CATALOG No. 45
AND TESTING HANDBOOK
JUST PUBLISHED
Request Your Copy



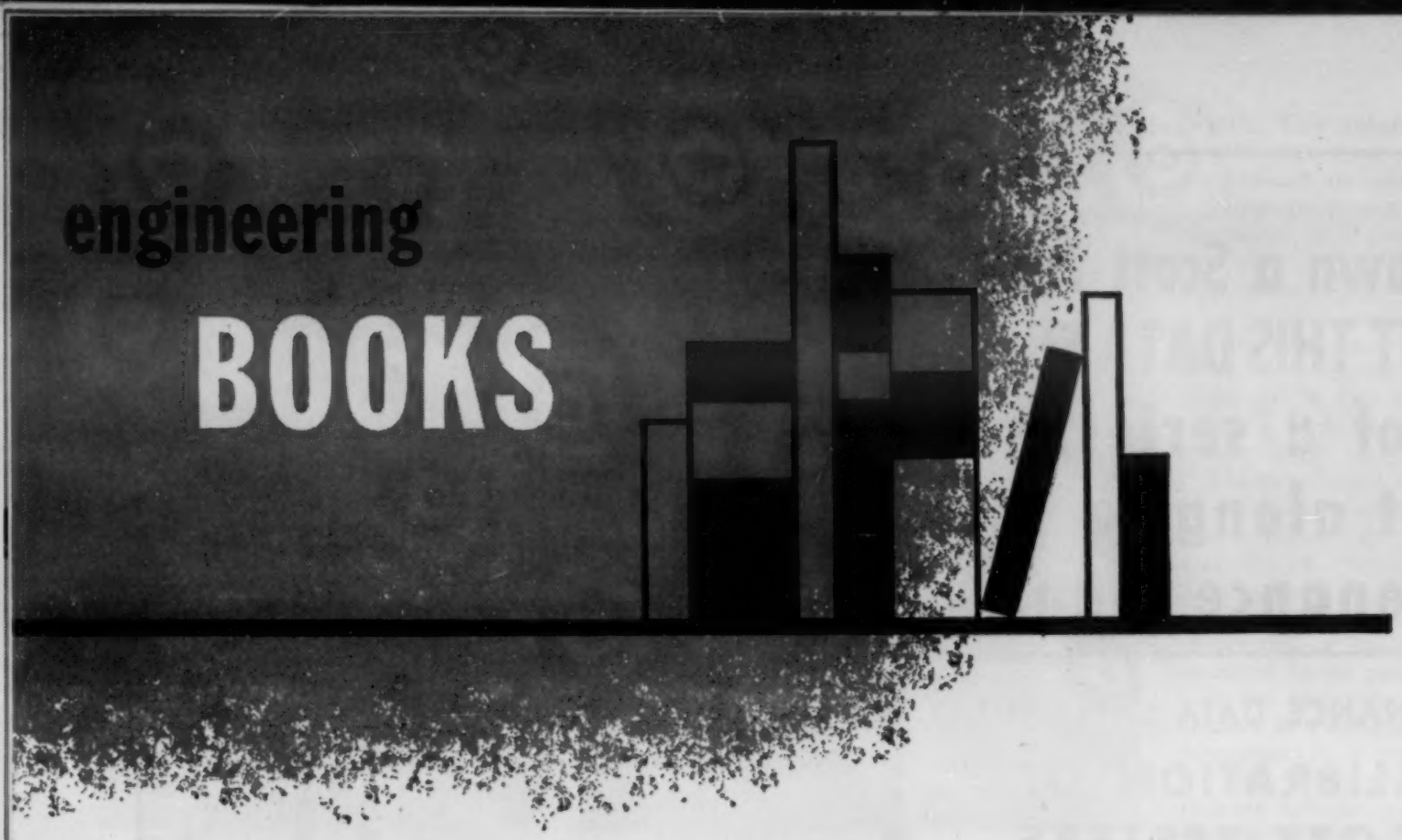
Contains full description of numerous standard physical testing methods and machines – plus a wealth of related reference data.

SCOTT TESTERS, INC.

65 BLACKSTONE STREET PROVIDENCE, R. I.

Scott Testers — Standard of the World

engineering BOOKS



Electroplating

Electroplating. 5th Edition. By Samuel Field & A. Dudley Weill. Published by Pitman Publishing Corp., New York, 1945. Cloth, 5 x 7 in., 483 pages. Price $5.00.

Obviously an attempt has been made to modernize this well-known book, but the effort relates principally to simple insertion of paragraphs here and there. Considerable of the old "art" is retained. One notable fact is the difference in terminology from that of American electroplating.

Undoubtedly, the authors attempt to cover too much ground, so that, generally, the reader must supply the essential detail from his own knowledge. Therefore, the general tone of the book is that of a "reminder," naming the topics on which knowledge must be possessed for technical qualification in electroplating.

But, as a reference book for American platers, it has serious shortcomings, since so little reference is made to modern methods and to the source of information. Practically none is made to outstanding work in recent American literature on electrodeposition and metal finishing. The work of many others is cited without reference.

Naturally, it is difficult to have any bound book right up to the minute. Yet, generally speaking, this one is a decade behind American practices for cleaning, polishing, and plating. Those references which are cited mostly antedate 1937. The chapters on cleaning, polishing, and silver, gold, nickel, alloy and zinc plating, all contain so much old material that it is difficult to draw conclusions on what the recommended practice would be.

A particularly commendable feature of the book is its extensive presentation of methods of analysis.

This book would not be placed on a list for recommended reading by platers who keep abreast of the times. Yet, if one takes the time to study the book, he would find buried remarks that throw out new information. To anyone in other fields of activity, the authors provide a good general picture of what electroplating involves.

—C. L. FAUST

Dictionary of Metals

METALS AND ALLOYS DICTIONARY. *By M. Merlub-Sobel. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y., 1944. Fabrikoid, 5¾ x 8¾ in., 238 pages. Price $4.50.*

The metallurgist frequently has need of a ready reference book to supply the meaning of an unusual term, or to classify an unfamiliar alloy. This little dictionary will meet that need. It contains brief but adequate definitions of 10,000—count 'em —10,000 metallurgical terms.

The book is not, and does not pretend to be, an encyclopedia of trade names, nor a formulary of alloy compositions. It does provide a compact listing that includes many of the more widely used trade names, terms in heat treating, metal refining processes, alloy types, and terms in the technical language of the metallurgist. It earns its place on the shelf of workbooks in the metallurgical laboratory.

—K. ROSE

Other New Books

LESSONS IN ARC WELDING—SECOND EDITION. *Published by The Lincoln Electric Co., Cleveland, Ohio, 1945. Cloth, 5¾ by 8¾ in., 176 pages. Price 50c in U. S.; 75c elsewhere.* This is a revised and up-to-date new printing of the second edition—it is not a new edition or a complete revision. There is, however, considerable new material in it. It should be of assistance to both new and experienced welders as well as to all persons interested or concerned with the subject. It includes 61 lessons in arc welding, and has over 200 illustrations. The closing pages contain 571 examination questions and answers.

HANDBOOK OF NON-FERROUS METALLURGY. RECOVERY OF THE METALS—SECOND EDITION. *Donald M. Liddell, Editor-in-chief. Published by McGraw-Hill Book Co., Inc., New York, 1945. Cloth, 6 by 9 in., 721 pages. Price $7.00.* A new edition of this handbook has been rendered necessary because of the improvements in the art of metallurgy. But considerable information has had to remain unpublished because of security considerations. The plan of the first edition has been generally followed in this second edition. There has been omitted any discussion of the working and the utilization of the metals after production—an attempt has been made to conform more closely to the idea of treating only of the reduction and of the refining of metals. The chapter in the first edition on Metallography has been omitted and one on Drying substituted.

PLATING AND FINISHING GUIDEBOOK—14TH EDITION. *Edited by N. Hall & G. B. Hogaboom, Jr. Published by Metal Industry Publishing Co., Inc., New York, 1945. Paper, 5⅝ in. by 7⅞ in., 258 pages. Price $1.00. (Free to paid-in-advance subscribers to "Metal Finishing").* This attractive guide book is full of information on plating solutions (arsenic, cadmium, chromium, copper, gold, indium, nickel, silver, tin, zinc and others), on plating calculations, on identification of deposits, on analysis and testing, on pickling and acid dipping, on surface treatments, on organic finishing, and so on. This edition is brought fully up-to-date. It will be helpful to all those interested in the plating field.

COLLECTED PAPERS ON METALLURGICAL ANALYSIS BY THE SPECTROGRAPH. *By D. M. Smith. Published by British Non-Ferrous Metals Research Assoc., London, 1945. Cloth, 6½ by 10 in., 162 pages. Price 21 s.* This volume contains a selection of 13 papers based on various reports made to the B.N.F.M.R.A., some coming from the Association's own research staff and some from laboratories of member companies. The reports are: Two on the processing and calibration of the photographic plates; four on the analysis of aluminum and aluminum alloys; three on lead and lead alloys; one on zinc alloys; two on copper alloys; and one on platinum. The book is not a systematic treatise on the spectrographic analysis of metals and alloys, but some of the papers offer practical recommendations. A wide range is covered, and the book will be of decided value to all interested in the spectrographic analysis of non-ferrous metals.

Portable Gas Pressure Determinator

For the rapid determination of the gas pressure created by molding sand or cores, a portable gas pressure determinator has been developed by *Harry W. Dietert Co.*, 9330 Roselawn Ave., Detroit 4. It uses a 1⅛ in. by 3 in. sand or core specimen, which is attached to the stem of the determinator. The specimen is then immersed in molten metal. The pressure of the gas envelope created by the specimen is shown on the gage of the determinator.

This determinator makes it possible to measure the pressure of the mold-metal interface gas envelope by a very practical method that simulates mold conditions almost perfectly.

The sand or core mixture to be tested is rammed to the chosen hardness. A special pedestal is furnished with the determinator which contains a hold to receive a specimen tube ¼-in. O.D. by 7⅛ in. in length.

The end of this tube projects 2⅞ in. above the special pedestal so that the open end of the tube is ⅛ in. from the top end of the rammed specimen. The specimen with the tube may be then dried or baked, if preferred, or attached to the determinator in the green state.

The tube with the specimen on one end is then inserted into the lower end of the determinator. A heat resisting gasket makes a gas tight joint. To adjust the tightness of this joint, one turns the handle of the determinator.

The specimen on the end of the tube is then immersed 2½ in. into a ladle of molten metal. The gas pressure created by the material under test is read in inches of water pressure on the dial of the determinator.

This method solves many perplexing problems as to the correct test temperature and test condition. Heat conductivity of the metal-mold interface is automatically taken into consideration. It forms a very simple, practical and economical test for measuring the gas pressure created by foundry sand or core mixtures, near the metal-mold interface.

Such tests as fineness, permeability, percentage of facing ingredients, moisture, and mold hardness all are considered to finally secure a desirable pressure of gas envelope surrounding the molten metal in the mold. Measuring the gas pressure is, therefore, a practical step.

Controller for Temperature Rise Rate

For batch-type processes and other operations where rate of temperature increase or decrease must be controlled, as well as the actual processing temperature and duration, *The Foxboro Co.*, Foxboro, Mass., has developed the "CycleLog" controller.

The name expresses the instrument's unique function—controlling and recording all the steps of a complete process cycle. No time-cams or supplementary instruments are employed. The control is completely automatic, according to whatever schedule is predetermined by adjustments of four setting knobs on the instrument panel.

In batch dying, the controller will bring the bath temperature up from any starting point, regardless of daily or seasonal variations, to the desired holding point, and do this at any desired rate of rise from 1 to 8 deg. F per min. It will then hold the bath at exactly the correct temperature for the correct period of time, and then shut off the heat supply, and signal the operator that the cycle has been completed. By reference to the instrument chart and its notations, any cycle can be exactly duplicated as desired, in any similar plant and regardless of season.

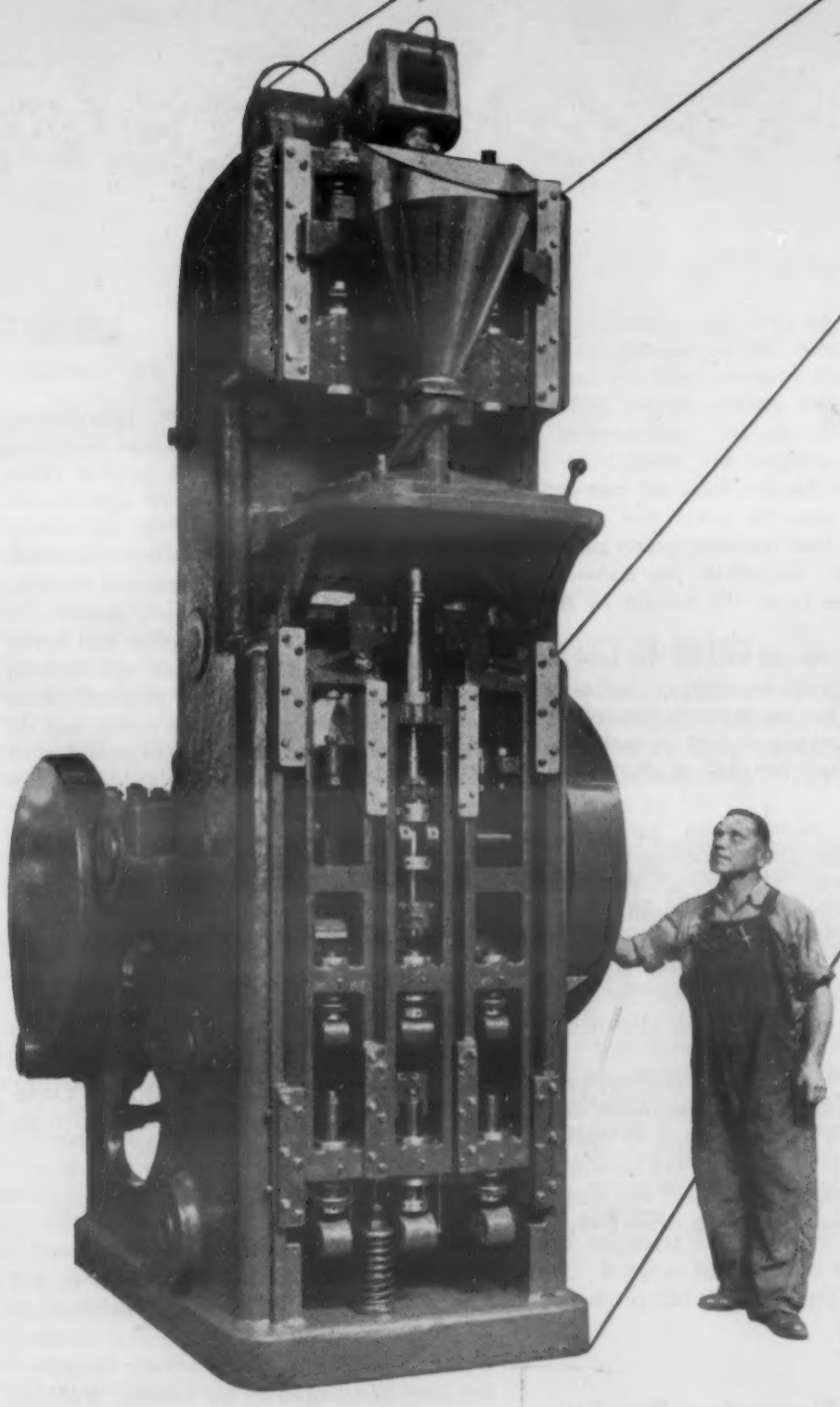
While other instruments have provided temperature control, with the deferred action and elapsed-time features, the "CycleLog" unit is unique in combining these with the new rate of rise control.

● A new arc-welding compound to aid in instantaneously creating and maintaining a metallic welding arc where low currents and small-diameter electrodes are employed has been announced by the Electric Welding Div., *General Electric Co.*, Schenectady. Known as "Strike-easy," it is easily applied and can be used on any kind of metal with any type of electrode. In paste form, it is available from distributors in 1-lb. glass jars, completely ready for use. No mixing or other preparation is required.

(More News on page 266)

PARTNER IN PROGRESS

Late nineteenth century metal-working machine.



Stokes "244" Powder Metal Press. Pressure is applied by multiple punches from both above and below for uniform density. Maximum pressure 85 tons. All Stokes Presses have a built-in safety factor, can operate at large overloads without appreciable deflection.

Advances in Metallurgy have helped build a new world. Stokes is privileged to have aided that progress.

The first automatic powder metallurgy press was developed and built by Stokes in 1920 . . . is still the basic design for production of porous bearings. Stokes presses have been engineered for many other applications . . . in the manufacture of iron gears, Alnico magnets, sintered carbides, machine parts, ordnance components, electrical contacts, etc.

Powder metallurgy, plus Stokes presses, makes possible operations otherwise impossible or too costly . . . such as combining hard-to-combine metals, controlling porosity and density, and combining metallic with non-metallic materials.

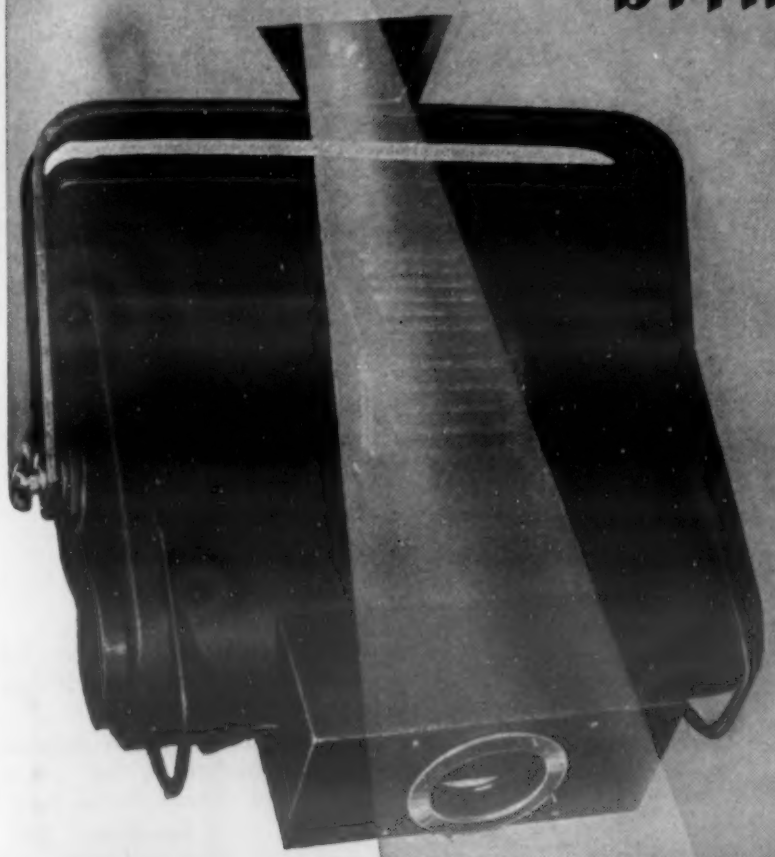
For machine recommendations, information on punch and die design, and advice on powder metallurgy applications, consult us.

F. J. STOKES MACHINE CO.
5972 Tabor Road **Philadelphia 20, Pa.**

50 YEARS
of Service To Industry
F. J. STOKES

Est. 1895

KELEKET brings to Industrial Radiography...



New Simplicity!

Self-contained tubehead, with built-in oil cooler, eliminates separate transformers.

Stepless push-button control provides infinite kilovoltage selection. Eliminates usual auto-major and auto-minor control dials.

New Dependability!

Power is instantly and automatically cut off at maximum tube rating. Prevents overloading of X-ray tube.

Pilot lights indicate not only when there is trouble, but show where the trouble is.

Automatic safeguard permits generation of X-rays only when cooling water is flowing.

New Efficiency!

Line compensator is adjustable while unit is in operation.

Constant milliamperage is provided by induction type filament regulators and filament compensating transformers.

X-ray inspection is made surprisingly easy with the new KELEKET 250 KV X-ray unit! It has ample power for the widest range of inspection requirements . . . yet it is the most easily operated unit in the entire field of industrial radiography!

The KELEKET control panel has only *half* as many controls as conventional equipment of similar capacity. With fewer controls to manipulate, your operator can concentrate thoroughly on the actual inspection procedure. And an employee can be trained in the shortest possible time to produce radiographs that are easy to read and of uniformly high quality!

This KELEKET 250 KV unit can be mounted on a jib crane or truck. Check (above) its many outstanding features . . . then learn how they will help you in your inspection work. Ask your KELEKET representative, or write us direct.

THE Kelley-Koett Manufacturing Co.

KELEKET-THE FINEST TRADITION IN X-RAY 2201 WEST FOURTH ST., COVINGTON, KY.

This

LIGHTWEIGHT INSULATING BRICK

does "Double Duty"

in Furnace Walls

CONVENIENT 13½ x 9" SIZE—EASY TO HANDLE

REDUCES WALL JOINTS 65%

Other forms of THERM-O-FLAKE INSULATION

Coating — Seals and Insulates all types of furnace walls. Highly plastic, works and spreads easily.

Blocks — Highly efficient insulation where larger size units may be required.

Concrete — Monolithic castable insulation with high insulating value.

Granules — Loose-fill, efficient insulation, weighs only 6 pounds per cubic foot.

Protects furnace steelwork and plating from excessive heat with a strong resilient cushion which absorbs expansion stresses.

KEEPS HEAT INSIDE FURNACE WALLS

Excellent insulation,— a 4½ inch thickness being equivalent in heat flow resistance to more than 29 inches of fire brick.

Find out how quickly THERM-O-FLAKE Brick will pay back their cost in reduced furnace heat losses. For specific data, indicate type of furnace and approx. operating temperatures in writing to:

Illinois Clay Products Company
JOLIET, ILLINOIS

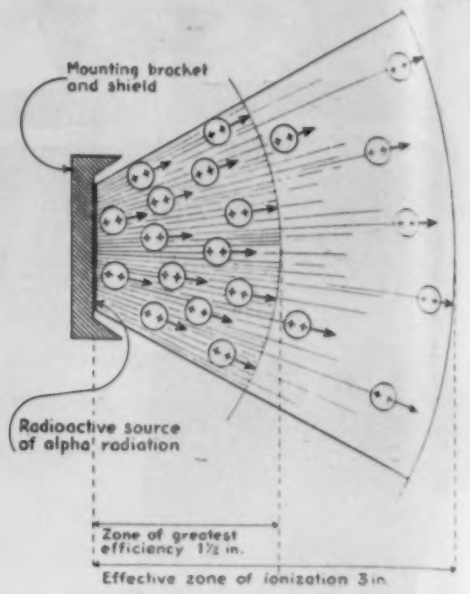
Therm-O-flake BRICK

FOR HOT FACE TEMPERATURES UP TO 2000° F.

Eliminator of Static from Machinery

Efficient, economical elimination of static electricity from machinery and from moving paper, plastic sheeting, textiles, and other materials is made possible with a new device, called the Ionotron static eliminator, developed by *United States Radium Corp.*,

IONOTRON STATIC ELIMINATOR


Mounting bracket and shield
Radioactive source of alpha radiation
Zone of greatest efficiency 1½ in.
Effective zone of ionization 3 in.

553 Pearl St., New York 7. The device has no moving parts and requires no electrical connections.

A continuous source of alpha radiation from a radioactive surface, in the form of a long, narrow strip, ionizes the surrounding air up to 3 in. from the surface. Effectual removal of static electricity within this zone is permanently assured in all applications, because the radioactive strength of the active element decreases only 50% in some 1600 years. It will be particularly useful where static is a possible cause of ignition of flammable solids, liquids, or gases.

The static-neutralizing element consists of extremely thin metallic foil, incorporating a radioactive substance and welded to a non-radioactive, metallic backing. The foil serves as a mechanical bonding medium for the radioactive material and acts as a seal to prevent escape of radon gas. Alpha radiation is emitted directionally, creating an ionized zone in the region of the electrostatic charge.

The assembly is mounted in a housing to provide adequate shielding, and can be supplied, within limits, in forms or shapes to meet special requirements.

Pre-Tempered Beryllium Copper

Beryllium copper can now be purchased in coils pre-tempered which requires no further heat treatment after fabrication. This pre-tempered beryllium copper has been well received by several fabricators who are now purchasing substantial quantities, and in their opinions, it has opened a new field for this alloy, as the heat treating and cleaning were definite drawbacks in many new applications.

The ductility of pre-tempered beryllium copper is much better than would be ex-

(Continued on page 270)

Houghton's Liquid Heat 1145 is INHIBITED AGAINST DECARB!

Users of salt baths for heat treating have long sought a material which stays neutral automatically for long periods. Former salts were "non-decarburizing" for a time, but did not stay that way indefinitely, and tended to shorten the life of pots and electrodes.

Houghton's Liquid Heat 1145 includes an inhibitor in its make-up which volatilizes under heat and disappears into the air, instead of building up objectionable alkalinity in the bath. Merely add 5% fresh salt daily, and your bath will stay truly neutral. No rectifier is required.

BRIGHT FINISH WORK

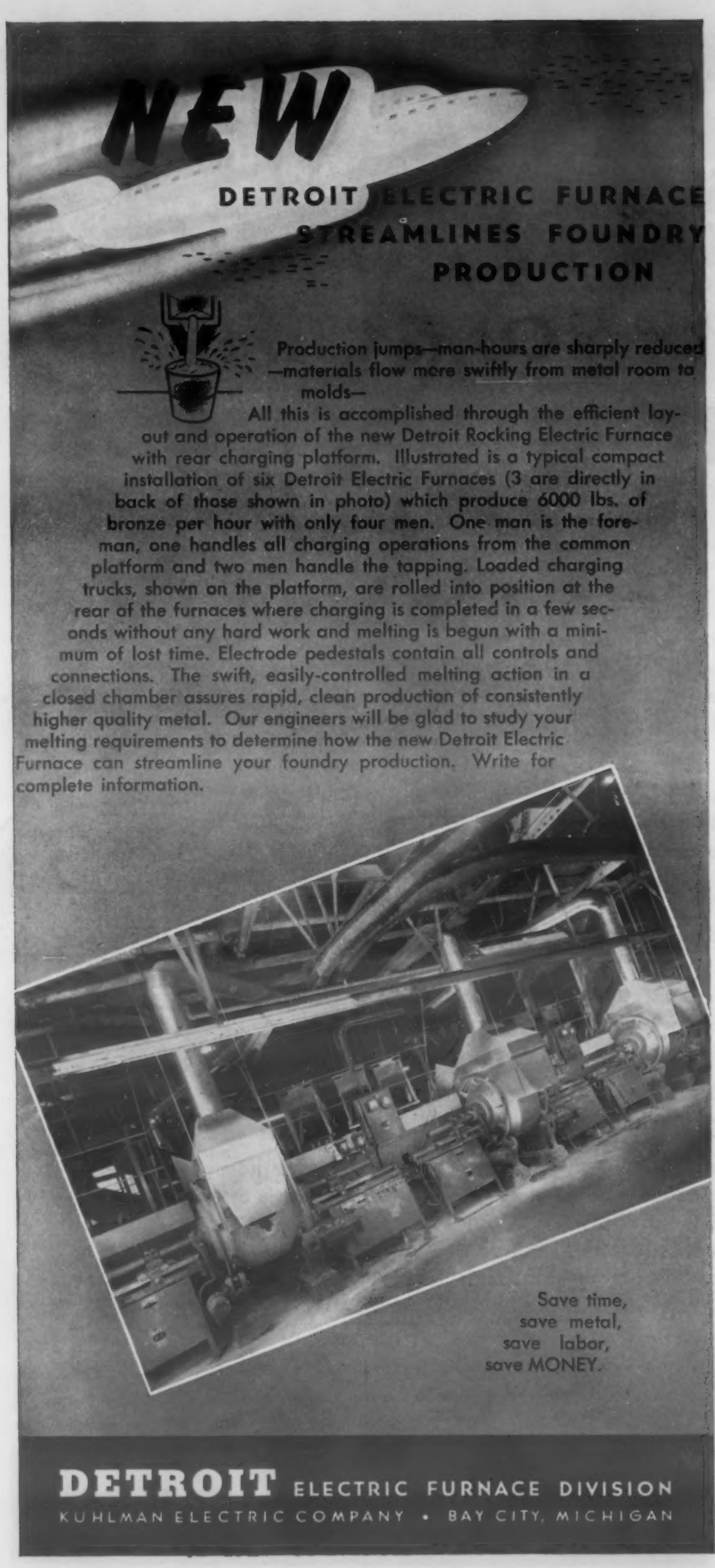
An added advantage of Liquid Heat 1145 is the bright finish it leaves on the work—much brighter than you are accustomed to after salt bath treatment.

DOUBLE POT LIFE

Experience to date indicates that pot life will be twice that afforded by former "neutral" salts. Electrode life is also lengthened, because the bath is never alkaline.

Liquid Heat 1145, already approved by several large heat treat departments, has a melting point of 1200° F., working range of from 1300° to 1650° F. It is very fluid—low carry-away loss and easy cleaning. Use it in metal or ceramic pots for hardening, and as a pre-heat bath for High Speed Steel. The Houghton Man can give you full details. E. F. HOUGHTON & CO., Philadelphia, Chicago, Detroit, and San Francisco.

HOUGHTON'S *Liquid* SALT BATHS


NEW
DETROIT ELECTRIC FURNACE
STREAMLINES FOUNDRY
PRODUCTION
Production jumps—man-hours are sharply reduced
—materials flow more swiftly from metal room to molds—
All this is accomplished through the efficient lay-out and operation of the new Detroit Rocking Electric Furnace with rear charging platform. Illustrated is a typical compact installation of six Detroit Electric Furnaces (3 are directly in back of those shown in photo) which produce 6000 lbs. of bronze per hour with only four men. One man is the fore-man, one handles all charging operations from the common platform and two men handle the tapping. Loaded charging trucks, shown on the platform, are rolled into position at the rear of the furnaces where charging is completed in a few sec-onds without any hard work and melting is begun with a mini-mum of lost time. Electrode pedestals contain all controls and connections. The swift, easily-controlled melting action in a closed chamber assures rapid, clean production of consistently higher quality metal. Our engineers will be glad to study your melting requirements to determine how the new Detroit Electric Furnace can streamline your foundry production. Write for complete information.
Save time,
save metal,
save labor,
save MONEY.
DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY, MICHIGAN

pected, and in replacing other alloys has required no die changes. It is clean, bright and free from contaminating oxides, and has the same appearance as annealed material. When taken from the coil, it lays flat and has no cast to it.

Previously, the cold rolled beryllium copper had to be jigged, heat treated for 2½ hr. at 600 F., then pickled, washed and dried before further processing. The approximate cost for pre-tempered beryllium copper is 10% higher. This material was developed by a combination of rolling technique and a short induction period at low temperatures. The entire heat treatment cycle is done continuously in a few minutes.

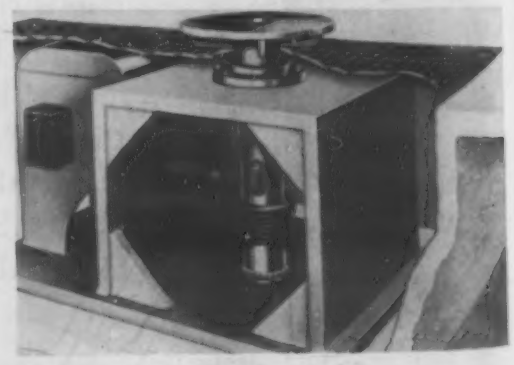
The process for pre-tempered beryllium copper was developed by George H. Slagle of the *Slagle Beryllium Co.*, Upper Darby, Pa., and patents are pending.

● A new emulsion-type cleaner, "PSC," for use in power spray washers and which cleans ferrous and non-ferrous metals and inhibits them against rust, corrosion and hand soil, is announced by *Phillips Chemical Co.*, 3405 W. Touhy Ave., Chicago 45. It is non-toxic, non-injurious to the skin, and requires no rinsing. A feature is the "blanket overflow" action wherein tiny particles of soil rise to the top of the solution and are periodically overflowed, thus keeping the bulk of the solution in the tank clean.

Centrifugal Casting Machine

A centrifugal casting machine engineered for heavier off-balance loads, for continuous high production and free-spinning power, is announced by the *Centrifugal Machine & Engineering Co.*, 678 Jackson Court, Kalamazoo 7, Mich. This "Centri-Meco" machine, weighing 3700 lb., is designed so that the standard 24-in. spinning head may be extended up to 60-in. diam. with an adapter plate.

The hub is turned of 7-in. mechanical tubing of ¾-in. wall thickness. It is heat free and provides for continuous production with permanent molds attached directly to

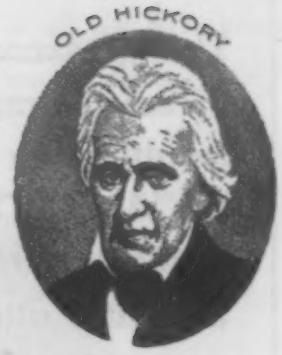


the heavy table mounting plate. Four strut vanes act as a fan to carry away excess heat, the temperature of the bearing area being held at not over 125 F.

The illustration shows the machine in the pit ready for operation, but without protective hoods and spill pans.

(More News on page 274)

May all your Clouds have a Silvery Lining during 1946



From Andrew Jackson's farewell address to his soldiers: *"Farewell, fellow-soldiers. The expression of your general's thanks is feeble, but the gratitude of a country of freemen is yours—yours the applause of an admiring world."*

·HIGH SILICON IRON·
"JISCO"

THE JACKSON IRON & STEEL Company
JACKSON, OHIO.

Cutting NITRIDING TIME CYCLES

with

"AMERICAN" DUAL PURPOSE FURNACE

Model NA Air Tempering Furnace With Nitro Attachments

The pressure system together with precision control of time, temperature and flow of ammonia gas are resulting in unequalled advantages to the users of "AMERICAN" Electric Nitro Furnaces, and the "AMERICAN" Electric Air Tempering Furnaces with the Nitro attachments.

ARMY E NAVY

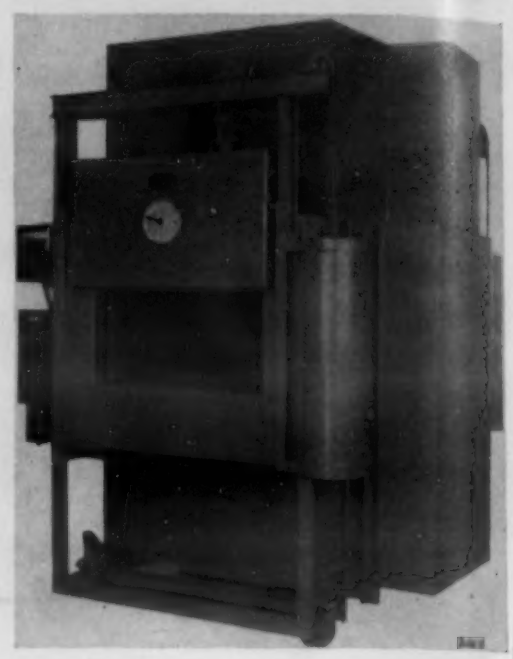
American Electric Furnace Company

29 Von Hillern St., Boston, Mass., U.S.A.

Industrial Furnaces for All Purposes

Furnace for Preheating "Mag" Sheets

The first of its type, perhaps—at least one of a very few units—is a magnesium sheet preheating furnace, a particular point of interest being the novel method of introducing the heated air into the furnace so that, whether the sheet is flat, formed or semi-formed, it will still receive uniform preheating. The furnace was made by



Despatch Oven Co., 619 S. E. Eighth St., Minneapolis 14, and installed at the Consolidated Vultee Aircraft Corp., Benbrook, Tex.

Automatic temperature control assures that the sheets will emerge from the furnace at the correct temperature. Being portable, it can be placed near the press brake, providing but little temperature drop from furnace to forming machine, and can be moved easily from one press brake to another.

By introducing heat into the furnace from the top and bottom, and with recirculating ducts on both side walls, uniformity ±5 F is obtained. A large fan provides over 40 air changes a minute.

High Pressure Degreaser and Cleaner

A new high pressure degreasing and cleaning machine, an electrically operated unit, develops 400 lb. working pressure in under 10 sec. and will handle all types and kinds of such cleaning, such as castings and equipment.

Made by *Drill Mfg. Co.*, 344 Circle Tower Bldg., Indianapolis, it has three units in one machine: degreasing and cleaning machine, built-in "presoaking" unit, and high pressure car washer, each function controlled by a 3-way valve.

It is portable and can be plugged into a standard light socket, no special rooms being needed. Absence of steam makes for good visibility. Best results are obtained when using the Drill No. 1 cleaning compound, which contains no acids, free caustics, soap or abrasives.

For stubborn dirt, a "Presoak" solution may be used which is in readiness in a built-in tank.

(More News on page 278)

Yes, it's an Alcoa Aluminum die casting

It's a frame for handling nine baking pans as a single unit

Aluminum's natural lightness and the thin sections in Alcoa's die castings make this frame easy to handle. Aluminum's superior thermal conductivity transfers heat to the baking pans in a hurry. Furthermore, due to the ability of ALUMINUM die castings to withstand the elevated temperature of the baking oven, permanent shape and the required strength are assured.

Alcoa's range of equipment for producing Aluminum die castings covers the field. The same care and know-how are employed in the making of the smallest as well as the largest of Alcoa's die castings.

Before you start detailing a new part, consult Alcoa on the possibility of producing it as a die casting. Often, a slight alteration in design makes possible a big saving in cost of the finished piece. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM

ROTOBLAST cleans by centrifugal force . . . without the use of compressed air . . . means *faster* cleaned forgings, stampings and heat-treated parts. It means *better* cleaned surfaces for *faster*, lower cost machining, grinding and processing. Cost-reductions over former cleaning methods are as much as 50% to 90%.

Because Pangborn Special ROTOBLAST Machines (like the one illustrated above which cleans more than 250 blocks an hour) are the answer to faster and cleaner production at lower cost, they are being ordered by forward-looking manufacturers. One of the leading automobile manufacturers recently purchased five additional Special ROTOBLAST Machines to clean cylinder blocks, transmission cases, transmission housings, etc. . . . and a well-known farm implement company just ordered three Special ROTOBLAST machines. Both these companies have used ROTOBLAST equipment for years.

Let a Pangborn engineer make a survey of your cleaning room problems. You profit when you "come to Pangborn".

* TRADEMARK OF THE PANGBORN CORPORATION

PANGBORN

WORLD'S LARGEST MANUFACTURER OF BLAST CLEANING AND DUST COLLECTING EQUIPMENT

PANGBORN CORPORATION · HAGERSTOWN, MD.

Welder for Rural Power Lines

A new low-priced welder for rural power lines, which overcomes objectionable features of previous welders for this purpose, is announced by *Lincoln Electric Co.*, Cleveland. Called the "Fleet-Arc Jr.," it is for 230 volt, single phase, power lines, and meets the limited input requirements of rural utilities and REA by a design of high efficiency and high power factor.

It has a maximum input current of 35 amp. and provides a machine that meets the new standards for this type of welder. It can be used with the standard 3-KVA power transformer provided by the power company.

Current range is from 20 amp. at 20 volts to 180 amp. at 25 volts welding duty. This gives sufficient capacity for all types of jobs found on most farms or job welding shops. It will handle electrodes ranging from 1/16 in. to 5/32 in. diam.

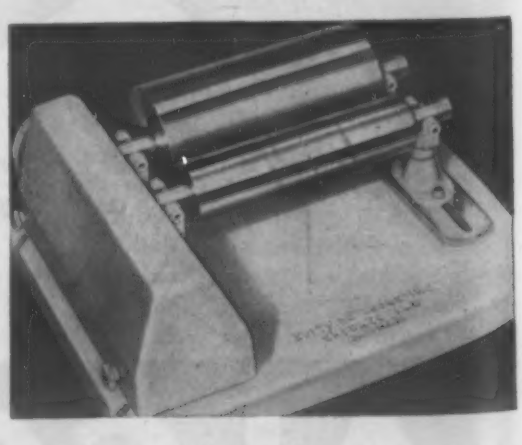
It inaugurates a revolutionary development known as the "arc booster," which provides quick, easy arc starting. The instant the electrode touches the work, the welding current is given a boost of intensity for starting the arc. The current then reverts automatically to the amount set for the job. No high voltages or special high frequency devices are used, the output voltage being limited to a maximum of 52 volts.

● *Du-Lite Chemical Corp.*, Middletown, Conn., announces a new method of preparing steel and zinc surfaces for organic finishes. Called "Phosteel," it is a phosphate-type protective finish, with low cost, simple to use, and with no license required.

Roller Lapping Machine

A new roller lapping machine simplifies and speeds up the slow job of lapping and polishing round plugs, pins or rods, turning out finished jobs in one-third the time needed by the old "ring lap" method. The machine is made by *Spitfire Tools, Inc.*, 2930 N. Pulaski Road, Chicago 41.

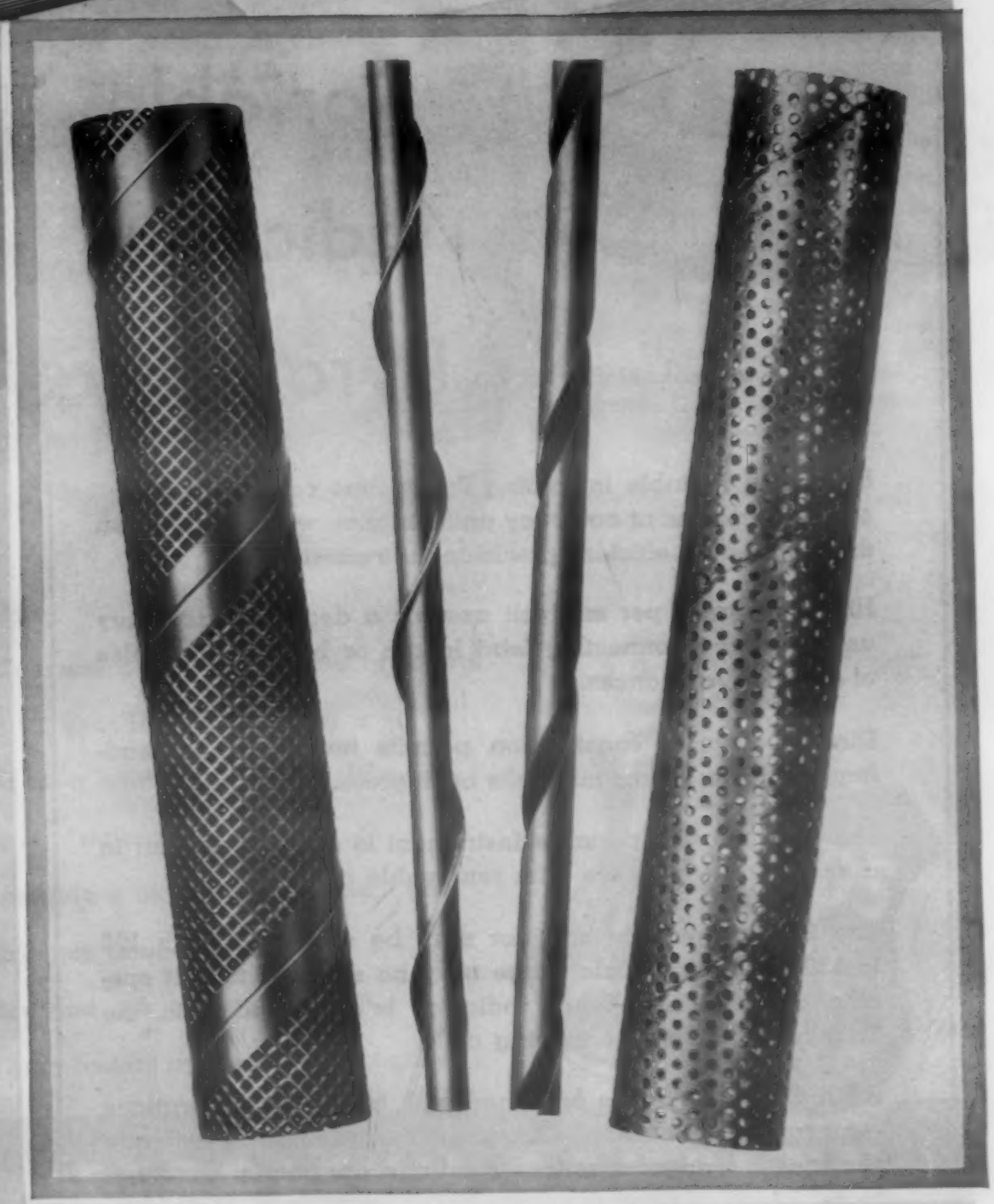
The machine consists of two precision ground cast iron rollers revolving in self-



aligning and adjustable bearings. Rollers are 12 in. long, one being 3 in. and the other 6 in. diam. Both operate in the same direction, away from the operator, at the

(Continued on page 282)

AGALOY DESIGN for PEACETIME



TUBULAR FORMS coiled from strip · Stainless steel · Monel metal · Carbon steel · Brass · Copper, etc. · A method originated by AGALOY in wartime.

The cost is low. The uses unlimited.

Manufactured in lengths to 22 ft.; 16 gauge; 4-inch outside diameter.

Write for literature describing Agaloy's complete line of cold drawn Stainless, Carbon and Alloy tubing.

AGALOY TUBING COMPANY

MILL: SPRINGFIELD, OHIO

NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.

CHICAGO OFFICE: 221 NORTH LA SALLE STREET, CHICAGO 1, ILL.

INSTANTANEOUS ACCURACY with ENGELHARD Portable Indicating Pyrometers

Engelhard Portable Indicating Pyrometers combine the necessary attributes of accuracy and instancy which distinguish the completely efficient precision instrument.

High resistance per millivolt assures a degree of accuracy unaffected by connecting lead length or by thermocouples of different resistances.

Direct deflection construction permits instantaneous readings easily in either millivolts or degrees.

The conveniently portable instrument is a complete unit in a sturdy carrying case with removable cover.

The 6" scale length indicator may be calibrated with 100 to 150 divisions. Scale range may be selected to suit specific applications. Every indicator is equipped with the Engelhard frictionless moving coils.

All indicators may be furnished with two scale calibrations —for rare metal and base metal thermocouples. By a simple change of lead connections readings are made on either scale.

WRITE FOR BULLETIN 400

CHARLES ENGELHARD, INCORPORATED

90 CHESTNUT ST., NEWARK, NEW JERSEY

same r.p.m., and can accommodate work up to 6 in. diam.

It is best to grind the plug or pin within 0.0002 to 0.0004 in. of desired size and then lap to size. Abrasive compound is brushed even over both roller surfaces. The work is placed between the rollers; then a notched fibre stick is pressed down on it and moved slowly and evenly from side to side across the plug or pin. Friction of the rollers on the plug causes it to revolve. Difference in the surface speed of the rollers brings about a lapping or polishing action.

● A new miniature inspection lamp, the "Eder-Lite," makes possible inspection of hard-to-get-at places such as cylinders, gear housings, tubes, rifle barrels, with openings as small as 5/16 in. and recessing interiors. Small light reflecting and glareless metal protected tungsten bulbs attached to flexible or rigid extension make clear vision possible by steering them down the proper channels so that maximum light is focused on the proper place. There is protection from fire and explosion. It is made by *Harmon & Co.*, 6 N. Michigan Ave., Chicago 2.

9% Nickel Steel in Tubing

A new application of the recently developed 9% nickel steel tubing designed especially for sub-zero temperatures is announced by *Babcock & Wilcox Tube Co.*, Beaver Falls, Pa. This is the first time that this high nickel-bearing steel has been made available in tubular form.

Developed primarily to answer the pressure tubing needs of plants handling liquified gases or other low temperature fluids, the new nickel steel tubing exhibits good physical properties even at temperatures as low as minus 320 F.

The new product may be applied in low temperature work as a substitute for 18:8 stainless steel tubing, and it will have particular applications in oil refineries and the chemical industries. Probably it can be used for special pump tubing in oil wells where salt water and hydrogen sulphide in the oil fluid present a difficult corrosion problem.

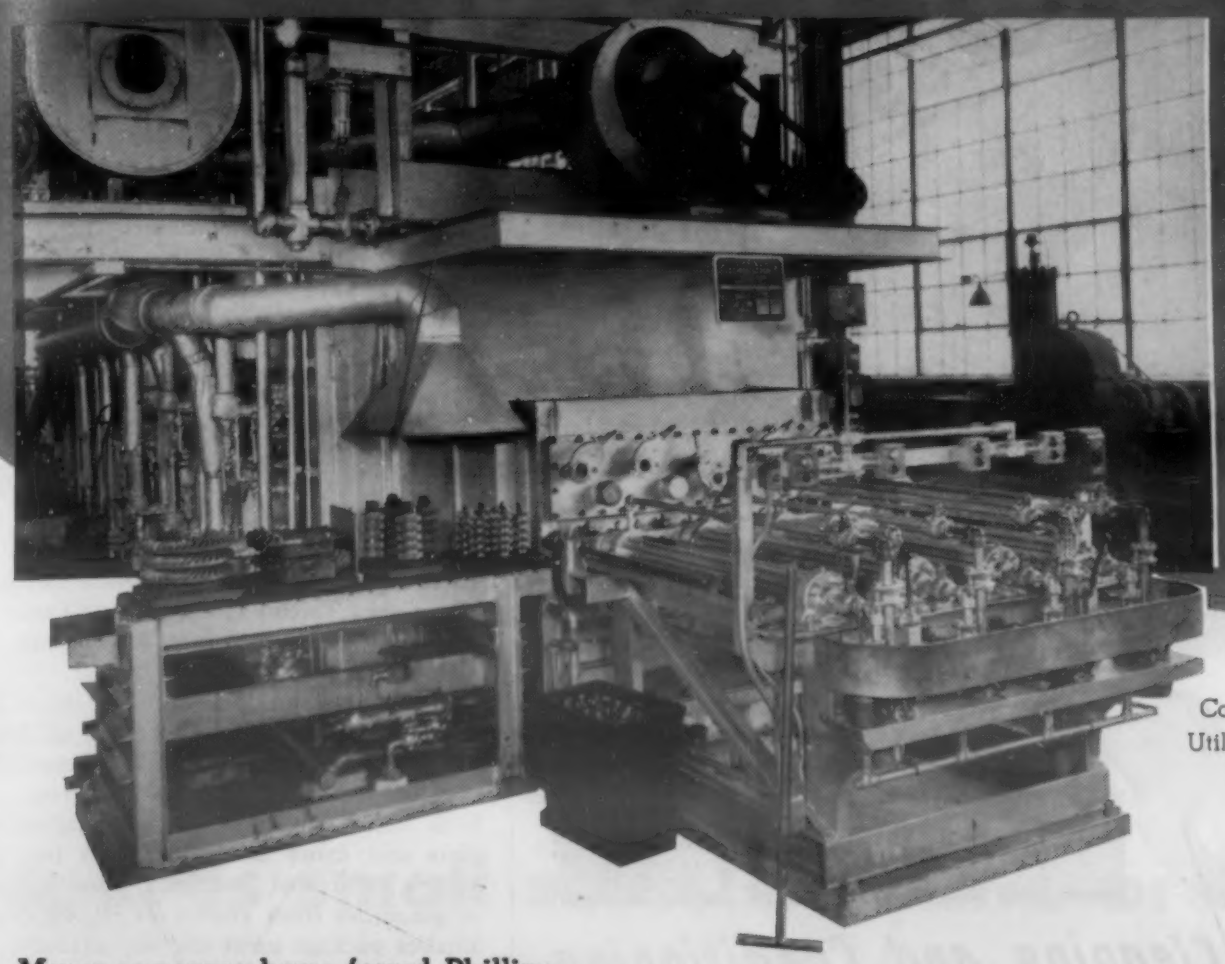
Other applications are in the tubes for black liquor evaporation (in the preparation of waste black liquor for burning in the Kraft paper industry), for caustic solution evaporation, and for alkaline-phenol solution work.

The new 9% nickel steel tubing is capable of giving Charpy impact values as high as 25 ft.-lb., even at the minus 320 F. temperature. The new alloy will offer resistance to attack by alkaline media and to low temperature embrittlement to a greater degree than any other nickel alloy steel tubing regularly produced by the company.

Development work in connection with the piercing, rolling and drawing of the new alloy steel has been satisfactorily com-

(Continued on page 286)

PHILLIPS PROPANE FOR *Carburizing*



Continuous Carburizing Furnace
Utilizing Liquefied Petroleum Gas
(Phillips Propane)

Many concerns have found Phillips Propane ideal for carburizing. Constant composition, ease of control and freedom from inerts result in excellent combustion efficiency when Propane is used as a heating medium. With air proportioning devices these "natural gases" may also be utilized to provide a high carbon content gas as the carburizing agent. Why not phone or write the nearest Phillips Branch Office and ask one of our engineers to discuss how your plant may benefit by the use of this gas?

Phillips
BUTANE
PROPANE

PHILLIPS PETROLEUM COMPANY

Philgas Division

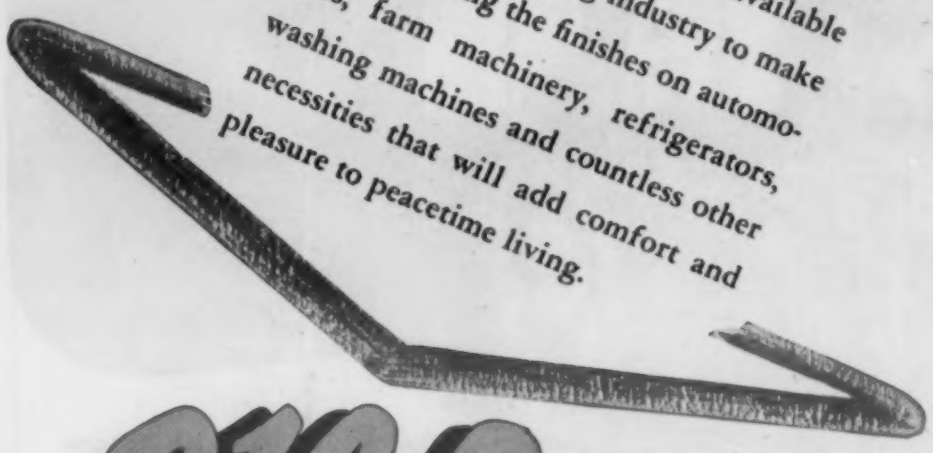
BARTLESVILLE, OKLAHOMA

Branch Offices in NEW YORK, CHICAGO, PHILADELPHIA, MILWAUKEE, DETROIT, ST. LOUIS, SHREVEPORT, AMARILLO, HIBBING, DENVER

THE WORLD'S LARGEST MARKETER OF LIQUEFIED PETROLEUM GAS

CHEMICALS
ACP
PROCESSES

ACP Chemicals and Processes that helped win the War are now available to the metal-working industry to make more enduring the finishes on automobiles, farm machinery, refrigerators, washing machines and countless other necessities that will add comfort and pleasure to peacetime living.



210 B DEOXIDINE

Assures Proper Cleaning and Conditioning

NECESSARY FOR PAINT PERMANENCE

210 B DEOXIDINE

Notable among these products is 210 B DEOXIDINE which has the distinct advantage of *cleaning* and *conditioning* at the same time; the combined operations are therefore carried thru in fewer stages — a saving in both time and equipment.

Power washers, heretofore used for alkali cleaning, are satisfactory — also the large machines built especially for handling large production of large surfaces. Ordinary mild steel equipment is adequate — stainless steel is not required but may be used if already installed.

To Aid Rapid Reconversion

The simplicity of equipment and operation of 210 B DEOXIDINE Process will be a material aid to the metal-working industry in reconversion to peacetime production. The low cost and excellent results obtained with Deoxidine for cleaning and conditioning were proved in wartime production.

ACP has served industry thru two World Wars and the intervening years of peace. This experience in the removal and prevention of rust, in inhibiting pickling acids and other applications of chemicals to the metal-working industry is available to you to help speed your reconversion to normal production.

Our Technical Dept. will gladly assist you in the most effective application of our products to your manufacturing requirements. Write Dept. G-1.

MANUFACTURERS OF INHIBITORS AND METAL WORKING CHEMICALS

AMERICAN ACP CHEMICAL PAINT CO.

Office and Warehouse 3665 Palmer Ave., Detroit, Mich. — AMBLER — PENNA. — Canadian Office and Factory Walkerville, Ontario

DISTRIBUTORS

West Coast: Leon Finch, Ltd., 728 E. 59th St., Los Angeles, Cal.
Metropolitan New York Area: Bricker & Andes, 318 Atlantic Ave., Brooklyn, N. Y.
Eastern Ontario and Quebec: Van Camp Products & Sales Co., 177 Parliament St., Toronto, Ont.

pleted. Finished normalized tubing shows very satisfactory physical properties and withstands the usual deformation tests on flattening, flanging and crushing.

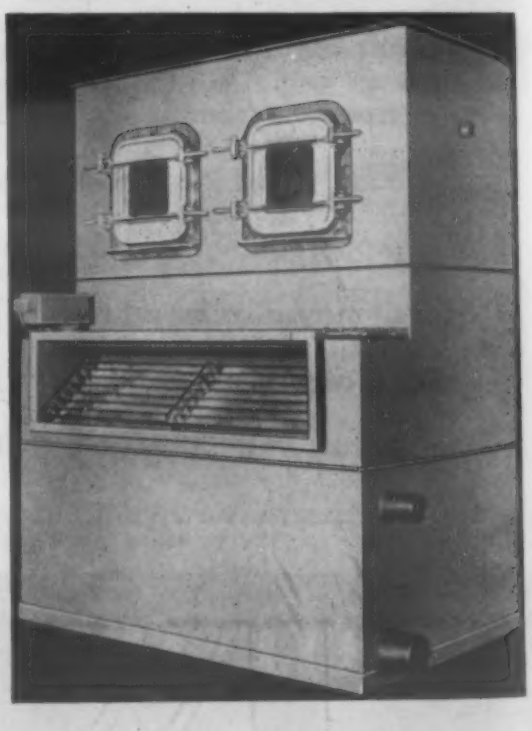
Minimum tensile properties of the tubing are specified as follows: ultimate strength, 80,000 p.s.i.; yield strength, 50,000 p.s.i.; and elongation, 20% in 2 in. The use of electric furnace steel only is recommended with nickel content ranging from 8 to 10% and carbon held to 0.12% maximum. The steel should be a fine grained type, irrespective of the end use.

● A new method of "bright dipping," which eliminates the fumes, danger and corrosion of conventional sulphuric and nitric acid formulae, is announced by *Waverly Petroleum Products Co.*, Drexel Bldg., Philadelphia 6. Several "Troxide" formulae have been developed. Costs are less than with conventional materials and processes.

Unit for Industrial Air Conditioning

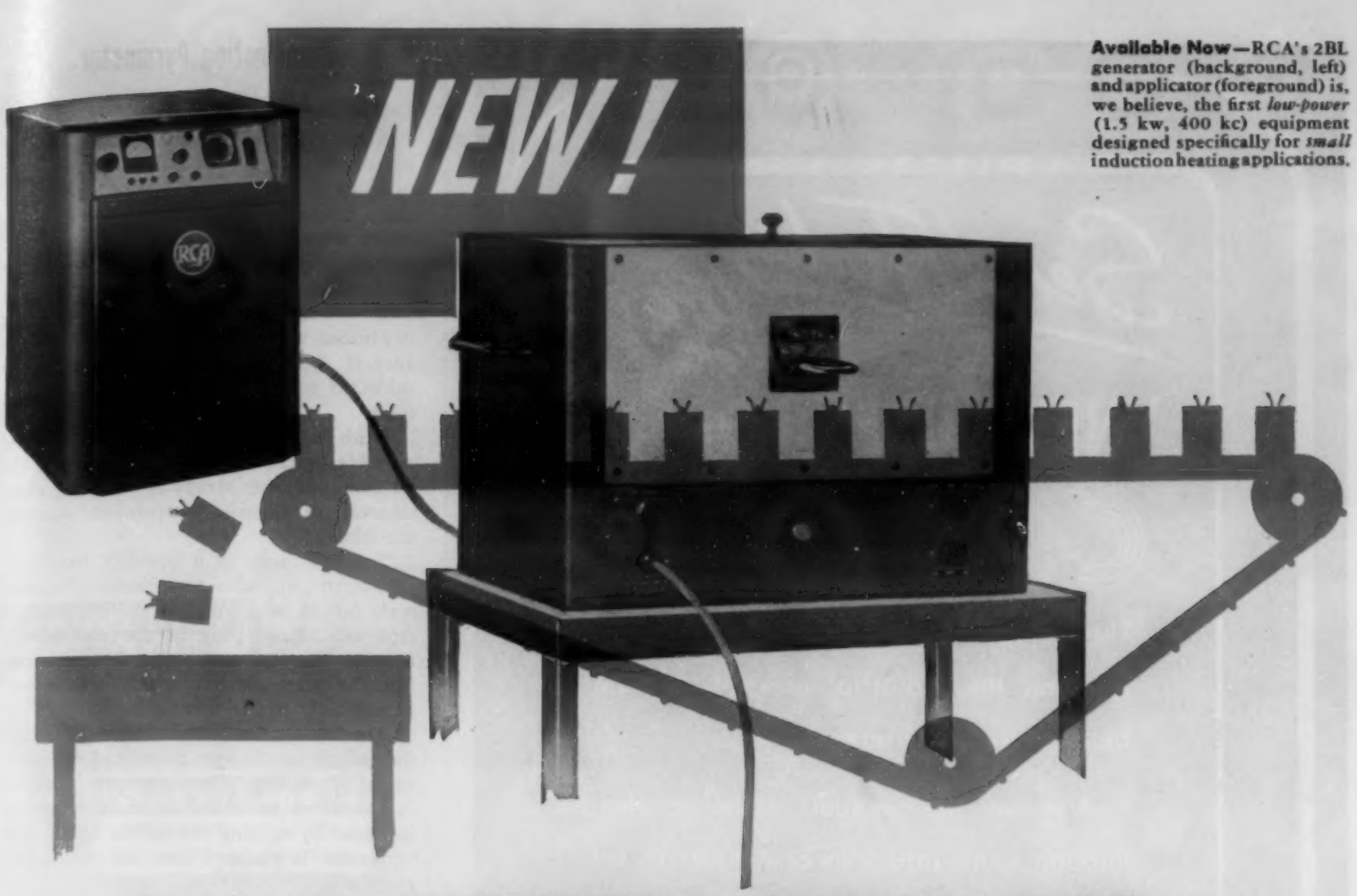
An industrial air conditioning unit for use where close control of humidity is necessary is sponsored by *Surface Combustion Corp.*, Toledo 1, Ohio. It is a vertical contactor of heavy duty construction, a member of the "Kathabar" system.

The system provides a reliable means for dehumidifying—humidifying the air independently of temperature. It is especially useful where low dew point air is required. It is useful in foundries, manufacture of glass and many other industries that require "controlled humidity" atmospheres in quantities from 10,000 to 70,000 c.f.m. Smaller package units are also available.



Air can be provided as low as 19 deg. dew point, or 6% relative humidity at 90 F. They have been tested at dew points as low as minus 80 F. The system utilizes an inherently continuous regenerative process, thereby eliminating cyclic operation common with drying agents.

(More News on page 290)



Available Now—RCA's 2BL generator (background, left) and applicator (foreground) is, we believe, the first *low-power* (1.5 kw, 400 kc) equipment designed specifically for *small* induction heating applications.

RCA ELECTRONIC GENERATOR

speeds small soldering and brazing jobs

YOU will find this equipment particularly useful for soldering and brazing such items as condenser cans, terminals, radiator valves, and watch cases. It can also be used to save time on small hardening, heat-treating, and welding operations.

As the applicator (work unit) is separate from the generator, unusual working flexibility is assured—the applicator can be mounted right next to the assembly line and the generator installed as much as 25 feet away (out of the high-priority working area). The foot switch connected to the applicator allows the operator free use of hands; all other controls—such as timing and output—are preset at the generator. A "universal" output transformer assures a match for any load, and eliminates the need for readjusting the generator during the heating cycle.

Installation is easy—just plug into any 230-volt, single phase, 60-cycle outlet and connect water supply to work coil. Installation supervision and operator training is provided at no extra cost to you. Also, a contract is available for complete service and maintenance by RCA.

Use the coupon below to get complete information on the other outstanding features of this equipment which contribute to its compactness, ease of operation, accessibility, low maintenance, and safety.

★ ★ ★

SEE THE 2BL at the Chemical Exposition in New York, February 25 to March 2 or at the Metals Congress in Cleveland, February 4 to 8.

FOR QUICK FACTS, CLIP THE COUPON

Radio Corporation of America
Electronic Apparatus Section
Dept. 52-A **Camden, New Jersey**

Please send me complete information on the new RCA 2BL electronic power generator for induction heating.

Name_____ Title_____

Company_____

Street Address_____

City_____ Zone____ State_____

RCA

ELECTRONIC HEATING

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DIVISION,
CAMDEN, N. J.

Send Today for

"NEW USES FOR... CERIUM"

This comprehensive survey of literature covering the industrial uses of CERIUM belongs in your reference file.

It describes the unusual results obtained through small additions of CERIUM to ferrous and non ferrous metals. It should be of particular interest to those working with aluminum and magnesium.

"New Uses For CERIUM" may be had without charge, on request.

*CERIUM STANDARD ALLOY

Containing 45-50% Cerium — Balance principally rare earth metals.

Also available

CERIUM MASTER ALLOYS

with

ALUMINUM • CARBON • COPPER • GOLD
IRON • LEAD • MAGNESIUM • MANGANESE
NICKEL • SILICON • SILVER • TIN

OTHERS ON REQUEST

The Source for Facts about Cerium

CERIUM METALS CORPORATION

522 FIFTH AVENUE

NEW YORK 18, N Y

Combination Pyrometer and Thermocouples

A special combination of portable "Alnor" pyrometer and thermocouples permanently installed in the heat zones provides dependable temperature measurement readings under severe operating conditions where a permanently installed instrument would be inadvisable. Excessive vibration, dust and dirt, fumes, lack of space, and similar conditions would affect pyrometer performance if the instrument were continuously subjected to these severe operating conditions.

With this new type of installation, the portable pyrometer is not subjected to the adverse influences except at relatively short intervals as periodic temperature readings are taken.

The pyrometer is a portable hand-held instrument, available in a choice of several scale ranges, and equipped with a bayonet type attachment plug at the end of the handle. The operator plugs the pyrometer into the receptacle box, which is connected permanently to the thermocouple.

Another type of installation with several thermocouples in heat zones can be wired to an Alnor Type T selector switch, allowing readings to be taken from successive locations by turning the switch knob. The pyrometer is plugged into the switch case receptacle.

This equipment is especially adapted to portable engine installations, and many uses in industrial plants where conditions are severe. It is made by *Illinois Testing Laboratories, Inc.*, 420 N. La Salle St., Chicago 10.

● An interesting reference chart on alloy welding, involving high and low alloy electrodes, has been issued by *Arcos Corp.*, 1515 Locust St., Philadelphia 2. Eight tables are devoted to: weld metal chemical analysis, corrosion resistance, ferritic electrodes for special purposes, alloy electrodes for surfacing, heat treatments, electrode identifications, welding current and arc voltage and lengths for various diameters.

Organic Soft Solder Flux

A new organic soft solder flux, more effective than common rosin fluxes, and which does not normally leave a corrosive residue on the work, is announced by *Superior Flux Co.*, Public Square Bldg., Cleveland 13.

Called "Superior No. 30 Supersafe" because of its activity in effecting the wetting of the joining surfaces, this flux, in many cases, contributes to easier soft soldering of metal combinations that have been considered difficult to solder. Another advantage is the complete absence of injurious deposit at the joint.

The effective acid action of the flux as it comes from the container is completely neutralized at ordinary soldering tempera-

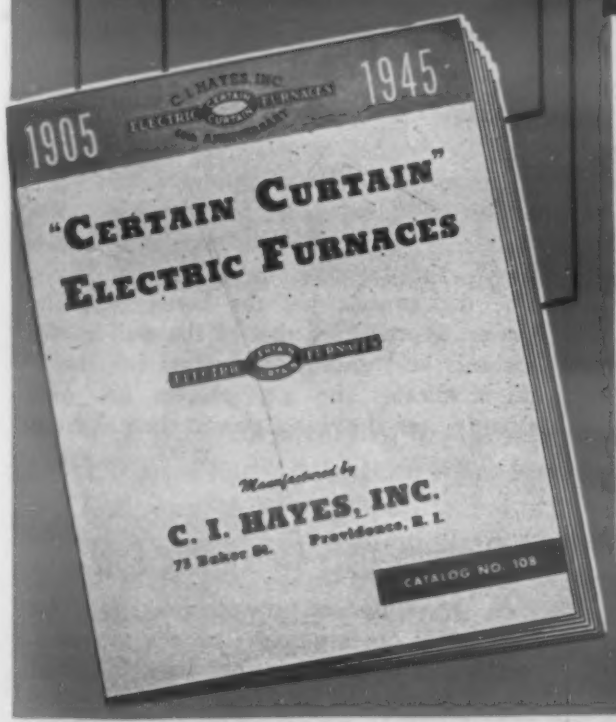
(Continued on page 294)

Send NOW for the "Certain Curtain" "Show in Print"

PAGES 1 to 7
"Certain Curtain" Atmosphere Control Methods and Data

PAGES 8 to 10
"Certain Curtain" Construction and Design Descriptions

PAGES 11 and 12
Inspection, Location, Placement of Furnaces



PAGES 13 to 20
"Certain Curtain" Controlled-atmosphere Furnaces for—

- High Speed Pre-Heating
- High Speed Hardening
- Carbon, Alloy and Stainless
- Tool and Die Hardening
- Recirculator Hardening
- Conveyor Hardening
- Vertical Hardening
- Annealing
- Copper Brazing
- Melting
- Sintering
- Tempering
- Tool Tip Brazing

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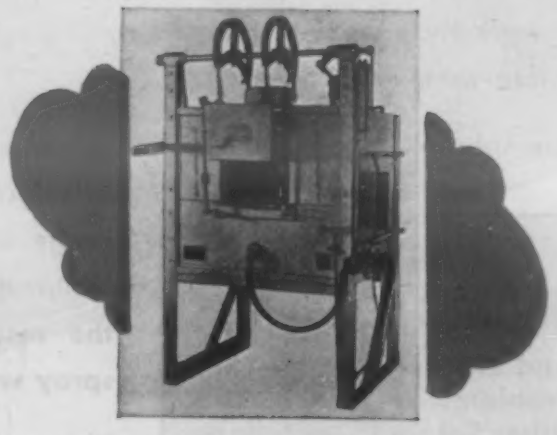
Brand New 40th Anniversary "CATALOG 108"



In this comprehensive catalog, you will find illustrated and described the latest up-to-date heat treating equipment based on the patented "Certain Curtain" furnace atmosphere control methods. It should prove a useful addition to your personal technical library. Sorry — Catalog 108 will not be distributed at the show.

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REDUCE your cleaning LOAD

The removal of smut, shop dirt and grease in a pre-cleaning operation using an OPTIMUS Solvent Cleaner will definitely reduce the "load" on your alkaline cleaning operations, provide increased production of cleaned parts, as well as a lowered overall cost.

Such an emulsifiable solvent can be used wherever the problem of degreasing is present. OPTIMUS Solvent Cleaners are ideal for the cleaning of die castings and screw machine parts.

These new Solvent Cleaners provide carefully blended mixtures, which when mixed in kerosene or other hydro-carbon diluent, remove soil from the work by effective solvent cleaning action. Their odor is clean—they are non-toxic and non-irritant.

These solvents when diluted with water may be used as a pre-soak prior to electro-cleaning to remove tripoli, rouge and similar buffing compounds. When mixed with kerosene and water, the resulting emulsion is effective in spray washing.

Let Dependable
OPTIMUS DETERGENTS*
and Processes Solve Your Problems in These and Other Related Operations

Cleaning metal before finishing
Preparation for welding
Ball Burnishing
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Cleaning for Maintenance and Inspection

* * *

In Hand or Machine Operations
In Metal Washing Equipment
Cold or Heated Tanks
Steam Cleaning Machines
Spray, Dip or Soak Operations

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**Available in Alkaline, Acidic, Solvent and Emulsion Types.*

Proper blending in their manufacture provides increased versatility in their selective attacking of the greases and dirts to be removed. They are stable and long-lasting.

Put your metal parts cleaning problem up to OPTIMUS metal cleaning specialists. The answer may provide savings in your operations as well as an efficient method of handling.

OPTIMUS DETERGENTS COMPANY

CHURCH STREET, MATAWAN, N. J.

ENGINEERS AND MANUFACTURERS

OPTIMUS DETERGENTS FOR INDUSTRY

tures, when properly used, leaving a residue that is normally non-corrosive, non-conductive to electricity, non-hygroscopic, and easily soluble in water. If after solder the work piece is well washed with water, all corrosion forming residues are completely and permanently removed.

This new flux is not offered as a general substitute for the commonly used zinc chloride fluxes, but is recommended particularly for applications where rosin-alcohol is unsatisfactory or where zinc chloride or similar strong acid fluxes cannot be used because of the corrosion factor. It may be used in soldering copper, steel, silver, brass, various alloys and electroplated parts, such as nickel plate, silver plate and cadmium plate.

The composition was developed by Battelle Memorial Institute in an investigation sponsored by the Tin Research Institute. So far, it has been largely used in war industries.

● Manodyz is an electrolytic process, offered by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J., which produces a protective and decorative magnesium-oxide-silicate film on magnesium alloys, the function being similar to the aluminum oxide film on anodized aluminum alloys. Either a.c. or d.c., which will deliver 4 volts to the Mandoyz tank, is needed. The d.c. process requires a current density of 10 to 20 amps. sq. ft.; the a.c. process requires a current density of 20 to 30 amps. sq. ft. Under normal operating conditions, parts may be completely processed in 30 min. The a.c. process is preferred with narrow gage wrought alloys (under 0.064 in.), while the d.c. process may be used with heavier gage wrought alloys and is preferred for castings and intricate shapes. The d.c. process has the better throwing power, approaching that of the well-known chromic acid anodizing process for aluminum alloys. The a.c. process has only slightly less throwing power than the d.c.

Heavy-Duty Metallizing Gun

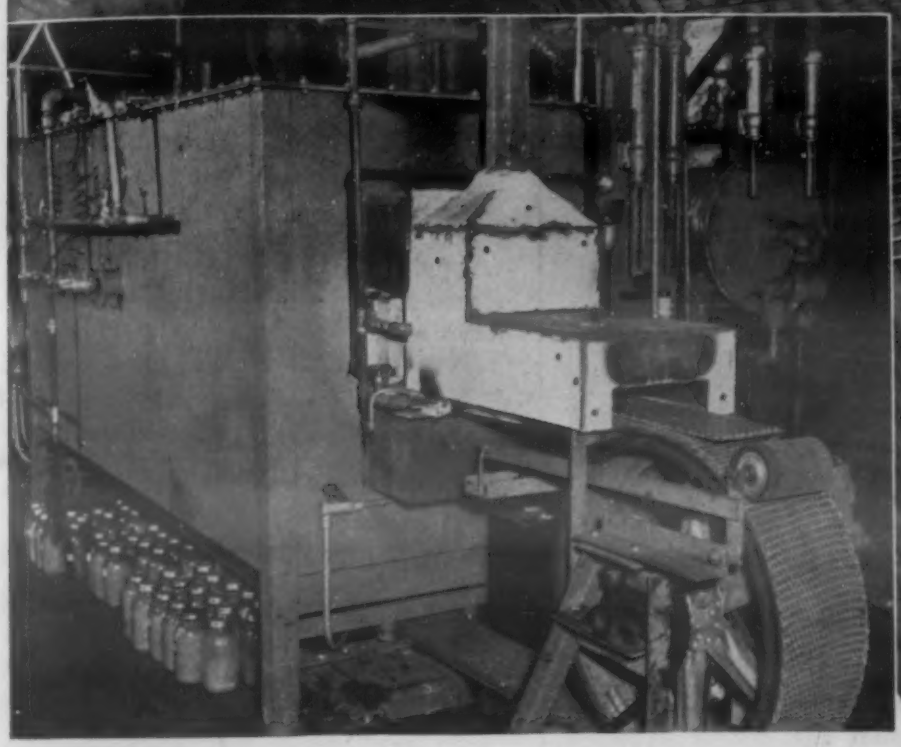
A revolutionary metallizing gun for heavy-duty operation, geared for mounted, mechanical operation rather than for hand use, is announced by *Metallizing Engineering Co., Inc.*, 38-14 Thirtieth St., Long Island City 1, N. Y. It provides for the use of 3/16-in. wire, which when combined with an acetylene pressure of only 15 p.s.i. more than doubles any previous spraying speeds.

The "Metco Type Y" gun is much heavier and more rugged in construction than the hand gun. Gears, worms and bearings are several times larger than any used previously, thereby virtually eliminating wear and replacement. "Fluid lubrication" and a built-in forced feed pump assures adequate lubricant to all bearings.

The gun is non-sensitive to gas and oxygen pressure variations, as much as 10 lb., either while lighting or spraying.

(More News on page 298)

40,000 SLIDE VALVES *Can't Be Wrong!*



The manufacturers of a machine used in the dairy business had a problem: what was the most economical way to produce slide valves in volume, to the tolerances and physical characteristics necessary. A cost study showed that this part was one of many that come within the economic range of powder metal production. The dies were made, the slides were pressed into compacts, then sintered in an electric furnace to produce atomic changes that made them hard, tough and dimensionally accurate, yet with enough porosity to hold lubricant. Produced by PMP in two operations, at a cost lower than by forging or other method (40,000 slides are shown above, ready for sintering in the furnace illustrated).

This is another example of the fact that powdered metal production is not limited to special alloys and mixtures of metals and non-metallic substances, not obtainable otherwise. There is a big field of application in cutting production costs on standardized small parts such as gears, cams, bearings, and complicated shapes.

Why not put your production problem up to PMP? We'll be glad to tell you whether or not your parts are suitable for powder metallurgy, and their costs on a production basis, Write for new bulletin showing how PMP solved a tough problem on the VT fuse, and peacetime applications.

PMP

POWDERED METAL PRODUCTS CORPORATION

1800 W. BERENICE AVENUE, CHICAGO 13, ILLINOIS

LEA is Standard Practice at

PACIFIC PUMPS, Inc. for finishing Hydraulic Actuator Pistons

● As with many other plants that had undertaken large and vitally important war contracts, PACIFIC PUMPS, INC., Huntington Park, California, promptly found some finishing problems on their hands. *And* as with many other plants, they turned to LEA of WATERBURY, CONNECTICUT, for the answer.

To finish actuator pistons properly and economically required just the right combination of wheel type, speed and finishing composition. A LEA Finishing Specialist suggested the proper procedure and helped work out the details.

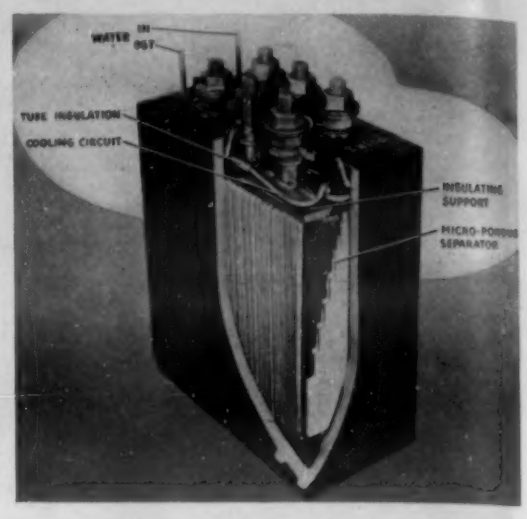
Finishing has been the Lea specialty for many years and the finishing may involve burring, polishing or buffing ... any one or all three. Our technical men have exceptionally broad experience and have many grades of compounds from which to select. That's why the name LEA is known throughout industry as "The Authority" on the subject of Finishing.

Is there anything we can do for you along these lines?

THE LEA MANUFACTURING CO.
WATERBURY 86, CONNECTICUT
Burring, Buffing and Polishing ... Manufacturers and Specialists in the Development of Production Methods and Compositions
11M-1

Cooled Batteries for Resistance Welders

A line of battery-powered resistance welders is now available with internally water-cooled storage batteries, having an effective capacity several times that of conventional storage batteries. The cooled batteries permit high charge and discharge rates, making possible increased output with fewer batteries, especially when welding



aluminum and other metals requiring high fusion currents.

These new Exide batteries were developed exclusively for *Progressive Welder Co.*, 3050 E. Outer Drive, Detroit. Other advantages are decreased battery maintenance and longer life, more constant operating temperature, reduction of evaporation and refilling required, as well as less hydrogen escaping under heavy duty operation.

Cooling of the cells is done by 50 in. of ¼-in. O.D. lead tubing in the electrolyte near the top of the cells (see accompanying cutaway photograph). Tap water is circulated through the tubing at a rate determined by requirements of the operation.

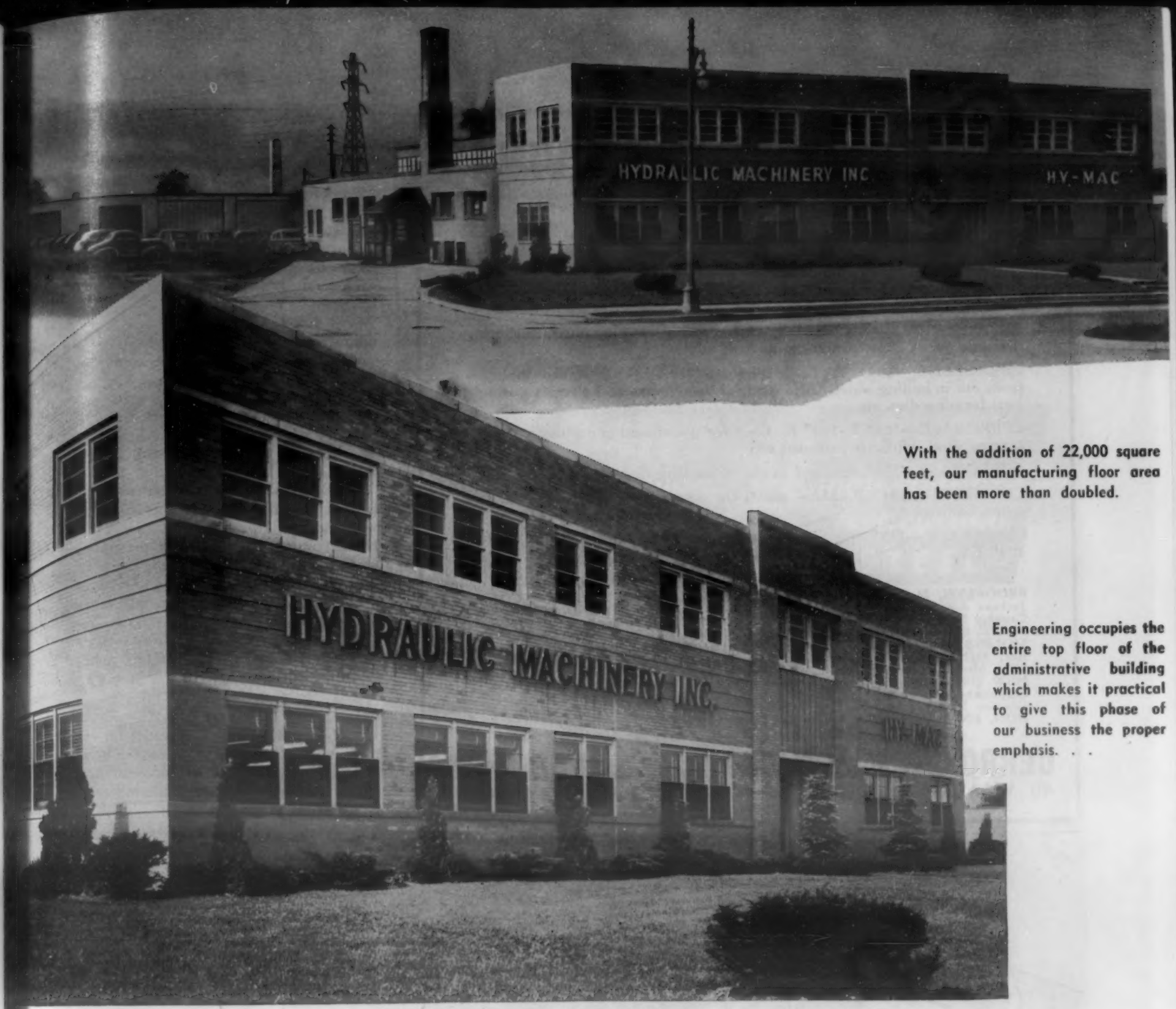
The lead tubing is insulated from the plates by insulators of special hard rubber, and from contact with the terminals by enclosing the tubing in rubber sleeves at these points. Positioning of the cooling circuit near the upper surface of the electrolyte also materially reduces the formation of water vapor and eliminates the excessive loss of electrolyte associated with uncooled batteries.

The new micro-porous separators used in this design withstand higher temperatures, provide better electrolyte circulation and lower internal electrical resistance better than the wooden separators commonly used.

Industrial Soldering Irons

An improved line of industrial soldering irons is announced by Industrial Heating Div., *General Electric Co.*, Schenectady. Ranging from 75 to 300 watts in size and available with tips from ⅜ to 1¼ in. diam., they are designed primarily for severe and exacting soldering operations in industrial plants where fast, continuous, high quality soldering is required. They are suitable for light, medium, and heavy intermittent soldering.

(Continued on page 302)



With the addition of 22,000 square feet, our manufacturing floor area has been more than doubled.

Engineering occupies the entire top floor of the administrative building which makes it practical to give this phase of our business the proper emphasis. . .

"HY-MAC" more than doubles facilities

for the building and designing of hydraulic and special purpose machinery . . . . . .

Our HOUSEMARK is emblematic of designer and manufacturer of Special and Hydraulic Machinery . . . Hydraulic Power and Test Units . . . Hydraulic Presses.

Moving machinery and equipment that has been busy at war work in two of our other plants, into the new building in Dearborn (Main Plant), provides us with more than double the facility for the building and designing of hydraulic and special purpose machinery in the RECONVERSION era. While this company is comparatively young in years, our "key" men in the various departments are old in experience and have a combined "know how" comparable to any in the field. . . . .

At the Metals Show . . . space B-720 . . . February 4th through 8th.

HYDRAULIC MACHINERY, INC.

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MANY USES — BIG SAVINGS WITH CERRO ALLOYS

LOW TEMPERATURE MELTING

CERROMATRIX—250° F. For securing punch and die parts; anchoring machine parts; short run forming dies; etc.

CERROBEND—158° F. As a filler for bending thin-walled tubing—melts out in boiling water. Also used for automotive and aircraft assembly jigs, forming dies, etc.

CERROSAFE—165° F.-190° F. Used for proof-casting cavities in molds, forging dies; duplicate patterns; etc.

CERROBASE—255° F. Used in electroforming dies, molds, etc.

CERROTRU—281° F. Metal molds for wax patterns used to make precision castings.

CERROLOW—117° F., CERROLOW—136° F. and CERROLOW—174° F.

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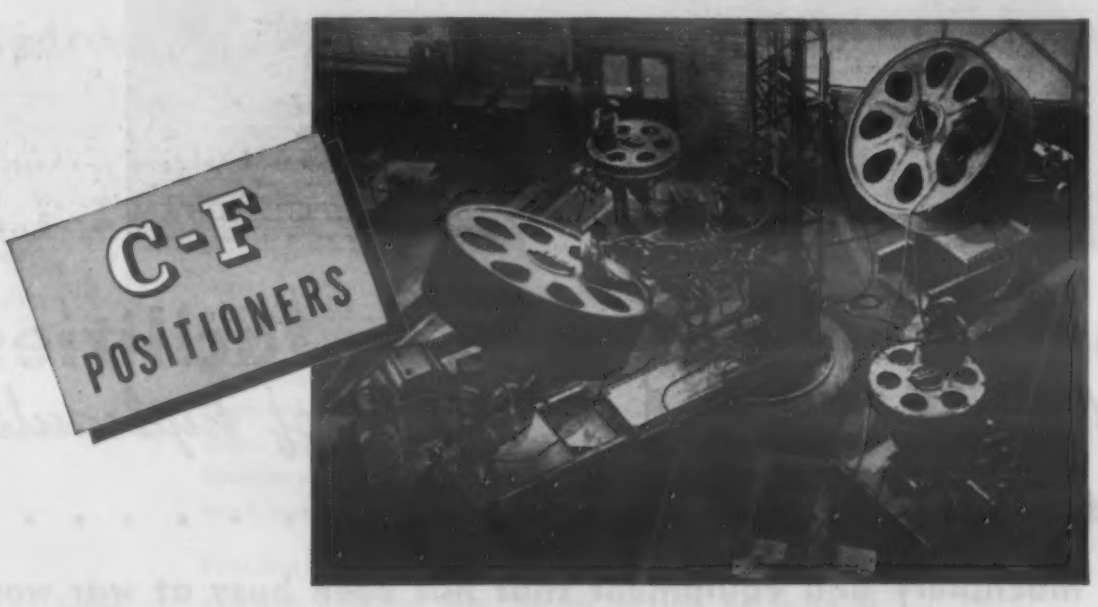

permit progressive automatic and hand welding

A "double production line"—in a 30 ft. square space handles all of the progressive steps of building up 2 sizes of large turbine gears simultaneously.

Four C-F Positioners are grouped radially around one automatic welding machine—2 No. 12s (1,200 lb. capacity) in diagonally opposite corners, 2 No. 140s (14,000 lb. capacity) in the other corners. With this arrangement, the single automatic welding machine can serve all 4 positioners and is used for all peripheral welds on the weldments. For this operation, the positioner rotates the tilted weldment under the electrode at any desired speed from 0 r.p.m. up. While the automatic welding machine is busy on one weldment, 3 welders are completing the hand welding operations on the other 3 C-F Positioners, which under push button control, turn and tilt weldment to any desired position permitting all welds to be easily made "down hand".

CULLEN-FRIESTEDT CO.

1314 S. Kilbourn Ave. Chicago 23, Ill.

They have quick recovery and high reserve-heat capacity, permitting soldering as fast and continuously as the character of the work allows. Used in these irons are calorized (surface-alloyed with aluminum) copper and 18:8 stainless steel for all parts subjected to high temperatures. This, together with the use of the Calrod heating unit, assures long life, uniform performance, low maintenance, and allows convenient renewal.

The heating units are easily replaced, as only one simple connection must be unsoldered to slip a new unit into place. The chisel-shaped copper tips are also calorized, which retards corrosion, facilitates easy renewal, and permits the tip threads from "freezing" to the tip holders. The irons are also furnished with iron-clad copper tips.

The working ends of these tips are surfaced with iron, which will not amalgamate with the tin in the solder, as copper does. Hence, pitting and erosion of the tips are obviated and, consequently, filing is unnecessary.

Sturdily constructed, these irons are well balanced and their plastic handles are cool and easy to grip, thus reducing operator fatigue and materially contributing to consistent production.

● A new electric-type controller for electrically heated furnaces is announced by the *Bristol Co.*, Waterbury 91. It combines a proportional current input controller and recorder in one case. It provides on-and-off type control with advantages of proportioning control. A rotating cam interrupts the flow of current to the heating coils, the duration of which is determined by the departure of the controlled temperature from the control point.

Pure Manganese for Stainless Steel

Cooperative tests with two steel mills have disclosed that pure electrolytic manganese, produced from low-grade domestic ores in a Bureau of Mines pilot plant at Boulder City, Nev., has definite advantages as a substitute for low-carbon ferromanganese in the manufacture of stainless steels, Dr. R. R. Sayers, director of the Bureau, states. The cooperating plants were the *Rustless Iron & Steel Corp.*, Baltimore, Md., and the *Universal-Cyclops Steel Corp.*, Bridgeville, Pa.

At the Rustless plant, 403,000 lb. of electrolytic manganese was added to 1,596 heats of 22 different types of stainless steel. At the Universal-Cyclops plant, electrolytic manganese was used in 103 heats, largely limited to two types of stainless steel. These steels were being made into welding wire for the Army and Navy, and the specifications required extremely low maximums of phosphorus and carbon, together with a relatively high manganese content.

Comparative heats using electrolytic manganese and low-carbon ferromanganese showed that there was no appreciable difference in the average recovery obtained from the two forms of manganese. As expected,

(Continued on page 306)

LET'S GO!

with these MODERN Free-Machining Open-Hearth STEELS

C-1113
MACHINING-CARBURIZING STEEL

C-1144
HIGH-STRENGTH FREE-CUTTING STEEL

IF you are looking for short-cuts in production, make a test run of these specially developed bar steels on your automatic screw machines.

C-1113 is a free-cutting grade of Open-Hearth Steel with a machinability rating of approximately 115% as compared to a standard of 100% for B-1112 Bessemer Screw Stock. This rating will be found to vary slightly with the type and extent of machine operations involved. C-1113 offers a substantial increase in output for parts requiring the physical characteristics of Open-Hearth Steel.

C-1113 has ample ductility to allow cold deforming operations, such as bending, nibbing or crimping. Thus it may eliminate the need for an annealing treatment when substituted for other carbon steels. Its response to carburizing and hardening treatments is equal to that of C-1117, C-1118 or similar grades.

C-1144 is a high-carbon, high-manganese, sulphurized Open-Hearth Steel, adapted for use in fabricating parts to be flame-hardened or induction-hardened. Because of its dependable machining quality and manufacturing economy, you can use it to advantage in a wide range of applications.

This part as formerly made from Bessemer Screw Stock had to be annealed prior to the deforming operation. By substituting C-1113, the dished flange can be cold pressed into shape, thus saving the cost of annealing.

This part, fabricated from C-1144 at a machining rate of 155 SFM, comes out with a bright, smooth finish, perfectly formed. The nose is induction hardened to resist specified conditions of wear.

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SPECIAL ALLOY FINISH

Entirely new development in wire coating that gives better than two to three times the rust resistance of tin. Smooth, satin finish that acts as a lubricant, reducing tool wear. Will not flake or peel. Used successfully where extreme acid or gasoline fume conditions exist. Coating does not affect physical properties. Solders better than tin.

A major wire development ... a better coating than tin ... can be substituted for tin. No government restrictions. Sizes .003" to 080".

JOHNSON STEEL & WIRE CO., INC.

WORCESTER 1, MASSACHUSETTS.

NEW YORK AKRON CHICAGO LOS ANGELES

however, they proved decided advantages for electrolytic manganese in meeting the low maximum specifications for phosphorus and carbon.

At both plants, electrolytic manganese was found to offer operating advantages because of its purity and physical form. It can be stored in less space and may be weighed more conveniently and accurately than ferromanganese. Weighing 20% less than an equivalent addition of ferro, electrolytic manganese requires less time to weigh and shovel, melts in more rapidly, and thus reduces chilling of the metal. No disadvantages were found in the use of electrolytic manganese at either plant.

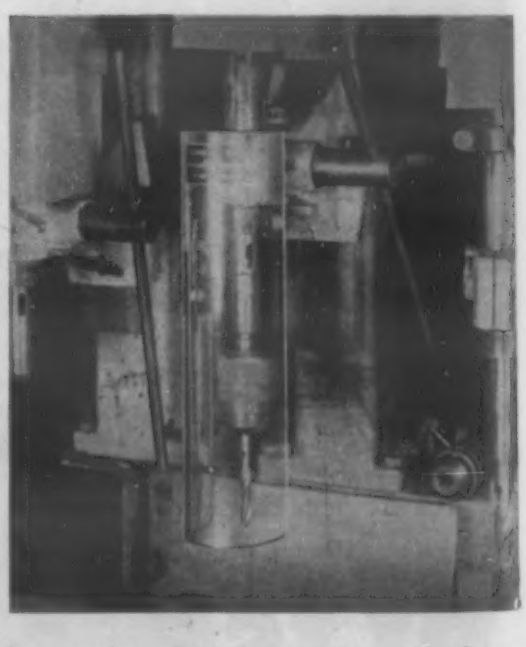
Despite the present higher cost of electrolytic manganese, the Rustless Iron & Steel Corp. now uses this form of manganese exclusively and the Universal-Cyclops Steel Corp. uses it for part of its manganese requirements in the manufacture of stainless steel. A substantial reduction in the price of electrolytic manganese can be expected when the metal is produced on a scale large enough to attain minimum costs.

A copy of Report of Investigations 3829, "Electrolytic Manganese in Stainless-Steel Tests at Rustless and at Universal-Cyclops Steel Corp.," by R. T. C. Rasmussen, may be obtained by writing to the Bureau of Mines, Department of the Interior, Washington 25, D. C.

Transparent Safety Guards

Too many guards for moving machinery hamper working visibility. Completely transparent are the new "Kleervu" guards made by *Wright-Austin Co.*, 345 W. Woodbridge St., Detroit 26. Sparks, metallic particles, splashing liquids and the like are not permitted to come into the open, but are curtained by an invisible chip-proof barrier.

The material from which guards are fashioned is a heavy-gage plastic, clear as window glass but of amazing toughness and high resiliency. Its properties enable it to



be sawed or drilled as easily as wood, yet molded into practically any shape or contour.

The guards are available in a number of standard sizes, but can readily be supplied in size or shape to fit any machine.

(More News on page 310)

FREE!

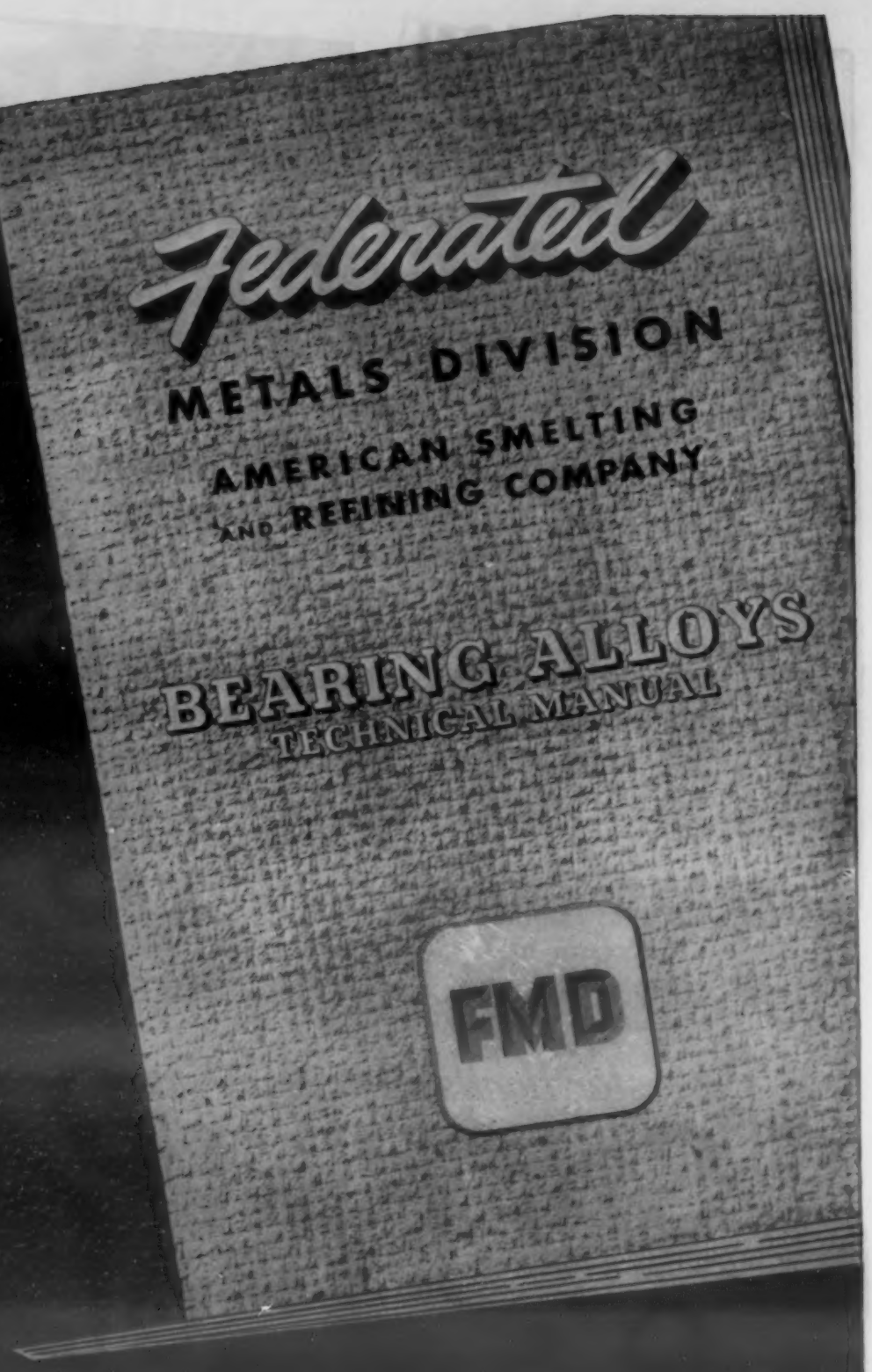
UP-TO-THE-MINUTE

FACTS

WAYS, MEANS, USES OF

BEARING ALLOYS

A detailed discussion of white metal bearing alloys—valuable to anyone concerned with production, maintenance, and repairs.



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Meetings and Expositions

INSTITUTE OF SCRAP IRON & STEEL, INCORPORATED, convention. Chicago, Ill. January 21-25, 1946.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter convention. New York, N. Y. January 21-25, 1946.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, annual meeting. New York, N. Y. January 28-30, 1946.

INSTITUTE OF THE AERONAUTICAL SCIENCES, annual meeting. New York, N. Y. January 29-31, 1946.

SOCIETY OF THE PLASTICS INDUSTRY, Low Pressure Industries Div. meeting. Chicago, Ill. February 1-2, 1946.

AMERICAN SOCIETY FOR METALS, annual convention. Cleveland, Ohio. February 4-8, 1946.

NATIONAL METAL CONGRESS AND EXPOSITION. Cleveland, Ohio. February 4-8, 1946.

AMERICAN INDUSTRIAL RADIUM AND X-RAY SOCIETY, annual convention. Cleveland, Ohio. February 6-8, 1946.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Iron & Steel and Institute of Metals Divs., national meeting. Chicago, Ill. February 25-28, 1946.

AMERICAN SOCIETY FOR TESTING MATERIALS, Committee Week. Pittsburgh, Pa. February 25-March 1, 1946.

EXPOSITION OF CHEMICAL INDUSTRIES. New York, N. Y. February 25-March 2, 1946.

Plants and Slants

After V-E Day many war plant workers worried about cut backs in production and how it would affect their jobs. At the Dobbs Ferry, N. Y. plant of the *North American Philips Co.*, the company established a "Rumor Box" into which mentally-disturbed employees deposited slips of paper on which they had written "what they heard." Next morning at a group meeting department officials presented the true facts. Soon after the rumor box was installed whisperings ceased. The box was empty and worker morale improved 100%. There should be many peace-time applications for the box.

The up-turn in machine tool sales will not take place at least until next spring, it was predicted at a recent meeting of 60

(Continued on page 314)

These typical Apex ads, appearing month after month, give you the fascinating story of continuing Apex progress in achieving ingot perfection. They chart for you Apex achievement via moden science —with Research Leadership Back of Every Ingot.

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Our capacity for deep drawing is 54" diameter x 18" deep, or 39" x 72" x 12", in all metals, and up to 7/16" gauge. *OVER 200,000 SQUARE FEET OF FLOOR SPACE!*

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- Hitherto the distribution of O.F.H.C. Copper has been restricted to certain special end uses such as electronics.
- O.F.H.C. Copper and a few special dilute alloys thereof are now available for most uses.

THE AMERICAN METAL COMPANY, LTD.

61 Broadway, New York, N. Y.

field representatives of *Warner & Swasey Co.*, Cleveland. Sale of new machine tools over the country during the first quarter of 1946 will remain at the same level as for the preceding three months. Increased purchases at Philadelphia will be offset by reductions at Pittsburgh and Cleveland. There is a rising trend to replace obsolete equipment with new types of tools. Uncertainty regarding labor-management relations and prices hold back orders.

John M. Olin, president, *Olin Industries, Inc.*, states that his company cannot purchase or lease the Tacoma aluminum plant which it operated for the Government, Olin having been one of three private companies producing aluminum during the war. "The future of the commercial aluminum industry is too uncertain now to justify the enormous risks involved," Mr. Olin says. Primary and secondary aluminum in inventory and process in the U. S. is far beyond estimated postwar requirements, he says. Moreover, a company should have proper ore deposits, facilities for alumina production, reduction and fabricating facilities. Mr. Olin advises that the Tacoma plant be closed in a "stand-by" condition for emergency operation. The plant uses the Soderberg continuous anode process, producing 99.75% metal.

Heat Treat, Inc. has been formed at Detroit, headed by George S. Kendig, formerly heat treat supervisor with General Motors Corp., Louis Pavlock, same position with Sav-Way Industries, and N. A. Woodworth Co. They have purchased the Sav-Way heat treat plant at 1455 E. Nine Mile Road, Hazel Park, Mich.

The Faxfilm Co. has been organized at 1220 W. Sixth St., Cleveland, to manufacture and sell "Faxfilm," a permanent transparent plastic replica of the surface of metal to be studied. The inventor of the technique, Rex D. McDill, will be with the firm in an advisory capacity.

John D. Dale has been made president of the metal and chemical firms of *Charles Hardy, Inc.* and *Hardy Metallurgical Co.*, New York. He was released from the Army on Nov. 4, having been in Ordnance work.

The Sherman Industrial Electronics Co. has been formed at 503 Washington Ave., Belleville 9, N. J. for engineering, manufacturing and service, specializing in electronic heating. It is headed by Vernon W. Sherman, formerly with Industrial Electronics Div., Federal Telephone & Radio Corp.

Operations of *Ault & Wiborg Div., Interchemical Corp.*, and *Murphy Finishes Corp.*, were consolidated on Nov. 1 and will be continued by Interchemical Corp. Finishes Div. Headquarters are in the Empire State Bldg., New York.

Paul D. Zottu, 95 Country Club Road, Newton Centre, Mass., formerly chief engineer, Thermex Div., *Girdler Corp.*, Louisville, Ky., has entered the field of consulting industrial electronic engineering, specializing in induction and dielectric heating. He has been active in several technical societies.

(Continued on page 318)

Three billion pounds of Aluminum, expected to be realized as scrap from war production and surplus, should be recognized as *insurance for the future.*

The huge size of this "mine above ground" is industry's guarantee of safety in designing products to take advantage of the unique features of Aluminum Alloys. It is the public's assurance that Aluminum products will be available in profusion.

Properly re-alloyed, and correctly applied, these stock-piles will be the basis of unprecedented expansion in the use of high quality Aluminum Alloys.

Careful selection of the proper alloy and its application for each designing and manufacturing purpose are essential. To help solve these, and other casting problems, expert assistance is available to industry through members of this group without obligation. It will pay you to consult us.

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Kansas City 18, Kansas

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East Chicago, Indiana

Aluminum and Magnesium, Inc.
Sandusky, Ohio

The American Metal Co., Ltd.
New York City 6

Apex Smelting Co.
Chicago 12, Illinois

Extremely Pertinent!

If you have not read the brief report of Mr. J. R. Townsend, President of the American Society for Testing Materials, concerning the great difference he observed in German as compared to American manufacturing methods, you should read it. You will find it on Pages 44 and 45 of the October 1945 issue of the A.S.T.M. Bulletin.

By permission of that Society, we reproduce below most of one paragraph:

"The trend in American manufacture is toward the use of greater power, more automatic machinery, and a greater degree of mechanization of manufacture. This requires the production of an abundance of material of uniform dimensions and quality to be fed to this automatic machinery. It is only with such material that the automatic machines can work unattended and produce myriads of parts of identical form and quality. To control the uniformity of the raw material it is necessary to develop methods of test. It is also necessary to develop and adopt methods of inspection and quality control. The core of the matter is the development of tests that can be used to measure and indicate variability in quality. This has been the primary concern of A.S.T.M. and our principal contribution to the war effort has been the preparation of such tests and the embodiment of them with proper tolerances into specifications. The use of quantity production and quality control of materials has resulted in the production of an overwhelming amount of weapons that could be used in the war."

We are not now at war nor preparing for it, but methods of manufacture are identical for war and for industrial peacetime production. Competition with Germany in armaments ceased when the war ended, but competition between American firms is starting now. These firms who follow most closely the successful American manufacturing methods are sure to win in peacetime competition.

See the "ROCKWELL" Testers in booth C-142 at the National Metal Exhibition.

WILSON
MECHANICAL INSTRUMENT CO. INC.
Sole Makers of "ROCKWELL" Testers
365 Concord Avenue, New York 54

An Associate Company of
American Chain & Cable

Myler Plastics Corp., 225 Broadway, New York, has broken ground for the first unit of its new plant at Plainville, Conn., where it will make equipment and compounds for production of low cost, high-speed automatic cold mold plastics articles.

Allegheny Ludlum Steel Corp. has acquired the Arnold Engineering Co., one of the largest manufacturers of permanent magnets, thus expanding its line of magnet steels to include all types of hard and soft magnets, magnetic and non-magnetic alloy steels.

Rust Furnace Co., Pittsburgh, has started construction of three large industrial furnaces for Chicago Bridge & Iron Co. at Chicago, Greenville, Pa. and Birmingham and for stress relieving welded pressure vessels, pre-heating heavy plates and for alloy heat treating.

W. S. Rockwell Co. announces new general headquarters at 200 Eliot St., Fairfield, Conn., having consolidated several divisions.

Reynolds Metals Co. has acquired the Aluminum Products Co., maker of "Lifetime" aluminum ware, and will expand its facilities for mass production of cooking utensils. Reynolds has also leased Nitrate plant, No. 1, at Sheffield, Ala. from TVA for ten years with option to buy.

The *du Pont Company* will establish a general laboratory for service to the ceramics industry at Columbus, Ohio.

Parts Mfg. Co., operating a furnace brazing plant on the West Coast, has been purchased by Ellinwood Industries.

Curtiss-Wright Corp. has bought the Marquette Metal Products Co., Cleveland, maker of precision parts and assemblies for the automotive and aviation industries.

Pittsburgh Plate Glass Co. will treble the size of its factory at Kokomo, Ind. and will add facilities for the manufacture of a new line of rolled shapes from aluminum sheet or strip.

Briefs on Associations, Promotions and Education

The Society for Applied Spectroscopy was formed recently in the New York metropolitan area, with membership open to all having interest in applied spectroscopy. Meetings will be held the first Tuesday evening of each month. Among topics to be covered in symposia at the coming meetings are: Types of excitation, types of equipment, measurement of radiant energy, absorption spectra, and spectroscopic nomenclature. The secretary is Charles L. Guettel, Driver-Harris Co., Harrison, N. J.

Another new technical organization is the Society for Quality Control, a national body that was organized at Pittsburgh in October. The president is Edward M. Schrock, and the secretary-treasurer Ralph E. Wareham, 305 E. 43rd St., New York 17. The general intent of the society is to serve all those interested in quality control,

(Continued on page 322)

Bring your own sample to be descaled. See how this easy, economical process can work on your particular requirements.

When you visit the Metals Show, plan to see the new Du Pont Sodium Hydride Descaling Process in action! You'll find a show-size assembly of the process right on the floor—turning out descaled parts while you watch! Bring along a small sample to be descaled! In this unit, we can handle forgings and castings weighing up to 2 lbs.; sheet, bar and rods up to 10".

At the Show, you'll see how this *new* Du Pont Process operates. You'll see how this simple arrangement of equipment and chemicals produces clean, bright metal surfaces free of scale and smut. You'll see that it can be done during processing into stock or on finished articles—that a large volume of work can be handled in a single compact operation.

Du Pont technical men are ready to assist in the selection of suitable equipment for specific installations and with the operation and maintenance of the process. For some quick and interesting details about this process, send for our booklet, "Du Pont Sodium Hydride Descaling Process." Just clip coupon below and attach to your letterhead. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

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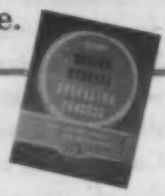

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Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Machines, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the machine of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.

Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The machine shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Machines and Vertical Retort Carburizers. Write for literature.

AMERICAN GAS FURNACE CO. PIONEERS 1878

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Main Office and Works: Elizabeth, New Jersey

giving particular attention to the needs of those in manufacture and inspection.

The Metal Treating Institute, 420 Lexington Ave., New York 17, has drawn up a "code of sound business practice," involving eight points.

The 20th Exposition of Chemical Industries will be held in Grand Central Palace, New York, Feb. 25-March 2, a show of raw materials, processing equipment and chemical products. Many new products and processes created by the war are expected to come out from under wraps and be applied to civilian operations. Many others, shelved during the war, are emerging as by-products, intended to round out the economic formulas. These will be on display at the exposition. The 20th exposition will be commemorative of the first exhibit of its kind, organized during World War I, under circumstances somewhat similar to the present. C. F. Roth is manager of the exposition.

A national fund campaign for $550,000 will be conducted for the establishment in Dayton, Ohio of the Cosmopolitan Research Center, to be the first of a series to be erected in different areas of the country. Testing facilities will be provided to allow amateur scientists a place to experiment, without charge. The president-treasurer is Alonzo D. Brewer, social scientist and graduate of the University of Pittsburgh.

Non-ferrous foundrymen have been offered cash prizes for best ideas regarding temperature control at pouring time. Among questions to stimulate answers are: In keeping close check on temperatures of molten metals is the quality of your castings improved? Have miss-runs become less frequent? Has the size of your scrap pile been diminished? The sponsor of the contest is L. H. Marshall Co., Station B., Columbus 2, Ohio.

Largest attendance in history is predicted for the 27th National Metal Congress and Exposition in Cleveland's Public Auditorium Feb. 4-8. Over 30,000 industrial visitors are expected and about 350 leading manufacturers will participate, or 25% larger than in 1944. It will occupy over 8 acres of display area. Thirty-one technical papers, four daily educational courses and three round table evening sessions will feature the American Society for Metals program. Other societies will have business or group meetings during the week.

The American Gas Assn. and the East Ohio Gas Co. are jointly sponsoring the "industrial gas center" at the National Metal Exposition and Congress at Cleveland Feb. 4-8. Papers will be delivered, expounding new ideas and new developments in industrial gas utilization.

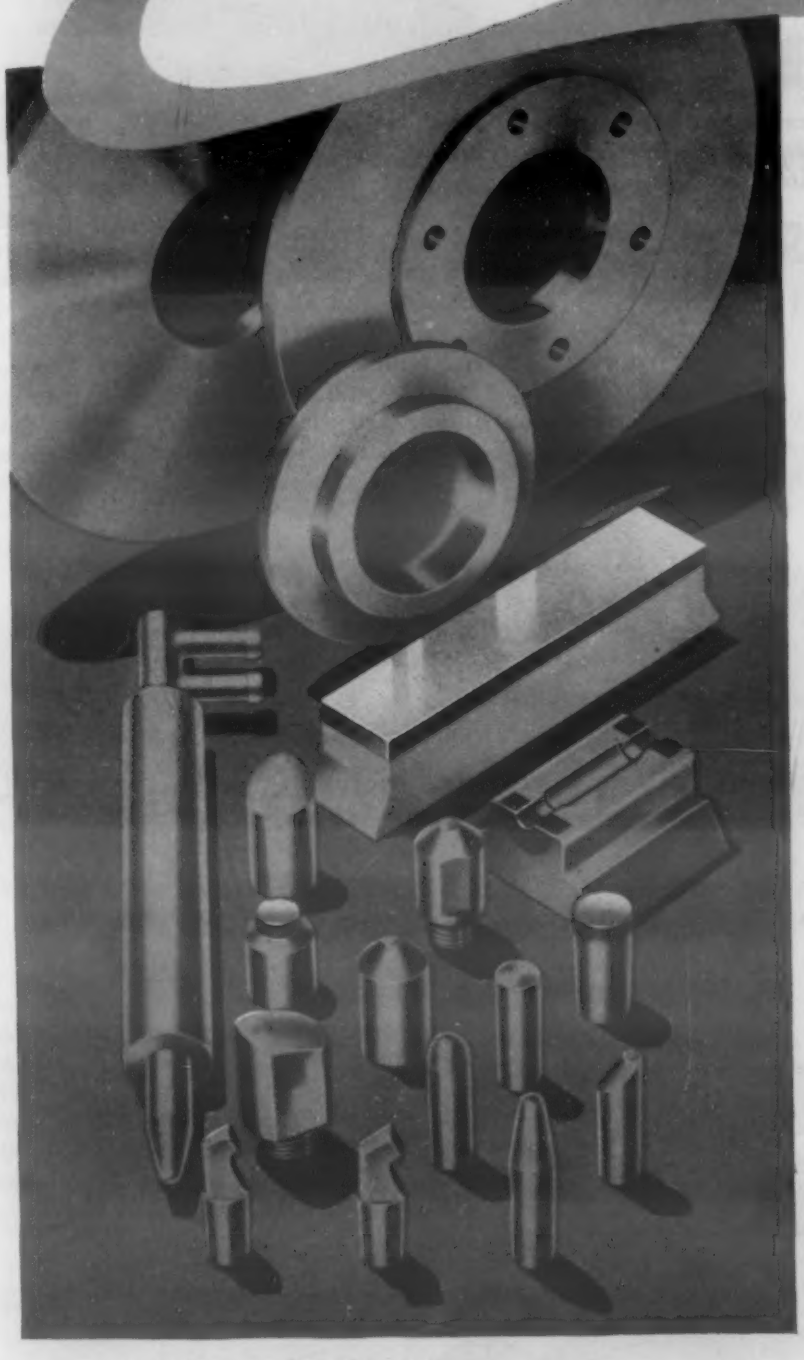
The Corrosion Forum, organized recently at Pittsburgh, is open to anyone interested in the problems of corrosion. On Jan. 14 the talk is scheduled to be on "Corrosion of Pipelines," by D. B. Williamson, Peoples Natural Gas Co. Information may be had from Richard Rimbach, 1131 Wolfendale St., Pittsburgh 12.

Upon accepting the Chemical Industry Medal for 1945, Sidney D. Kirkpatrick said: "With the release of atomic energy,

(Continued on page 326)

P. R. MALLORY & CO. Inc.

MALLORY INSURES MELTS!



The addition of Lithium makes it easier for P. R. Mallory & Co., Inc. to meet its high conductivity requirements in these spot welding tips, seam welding wheels, and projection, flash and butt-welding dies. Mallory engineers also use Lithium for thin and complicated castings of Mallory 3, because it improves the fluidity and prevents mis-runs.

It is no accident that Mallory alloys are noted for their uniformly high electrical conductivity and high strength. To *insure* this uniformity, Mallory engineers specify the incorporation of Lithium in their proprietary copper base alloys.

This is sound insurance, because Lithium treated melts of copper, tin bronze and silicon bronze consistently yield castings more uniformly free from porosity and gas cavities, with non-metallic impurities effectively removed, and with optimum physical properties . . . at a small fraction of the cost of *one* reject.

You might naturally expect a treatment so *effective* and *economical* to require a new and special technique. Actually, it is *simple*. Lithium treatment requires no special equipment, no special training, no departure from conventional foundry practice. Shortly before pouring, Lithium metal is stirred into the melt in the form of a stable master alloy containing a small percentage of Lithium combined with other metals to match the melt.

To help you investigate the advantages of Lithium treatment, we offer the services of our technical staff, with more than fifteen years' experience in finding the best practical answers to casting problems. Lithaloys Corporation, 444 Madison Avenue, New York 22, N. Y.

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the scientists want to become politicians and the politicians, scientists. On their record to date, the scientists have been none too successful with their political proposals, while the politicians seem to have increasing difficulty in organizing their facts—scientific and otherwise."

Before the American Management Assn. recently R. W. Mallick, of Westinghouse, stated that a unit of material averages from 20 to 150 handlings. For every 1000 lb. of material received at a plant, one pays for handling 20,000 lb. through a plant. All of which points out the need for efficient handling.

Louis Shattuck Cates, president, Phelps Dodge Corp., has been elected president of the American Institute of Mining and Metallurgical Engineers for 1946. He was awarded the William Lawrence Saunders gold medal in 1939.

The Packaging Exposition of 1946 will be held in the Public Auditorium, Atlantic City, Apr. 2-5, sponsored by the American Management Assn. It will be the largest show in the 15-year history of the exposition.

At a recent meeting of the Porcelain Enamel Institute it was said that the potential market for 1946 will be 40% above 1941.

The 1946 exhibit and conference of the Instrument Society of America will be held at Pittsburgh Sept. 16-20, inclusive. This is a new society, and its constitution is in the hands of 18 member societies for ratification.

Dr. Charles H. Herty, Jr., Bethlehem, Pa., has been elected national president of the American Society for Metals.

House Organ Notes

News Letter, Continental Industries, Inc., October, 1945.

The urgent need for cobalt anodes for an important research project was put up to Niagara Falls Smelting & Refining Corp. Several manufacturers had refused to try. Niagara at length ran a small experimental heat of cobalt, poured it into molds and after considerable experimenting were able to produce a cobalt casting. Cobalt in anode form is a tough steel-gray metallic element similar to nickel. Then they began to produce it on a quantity basis. The scientists declared it satisfactory for their use. Niagara was not satisfied because it was very porous. They experimented further with deoxidizing agents to remove gases absorbed by cobalt and with suitable fluxes to protect the molten cobalt from products of combustion while in the furnace. They finally produced 550 lb. of perfectly solid cobalt anodes with controlled grain size with fluxes in the furnace and a catalyst added to the cobalt before pouring.

Chrysler Tonic, Chrysler Corp., Nov. 27, 1945.

A recent study of the causes of 4,000 discharges by 76 employers revealed that 87% of the men and women were dismissed because they lacked certain character traits. Only 10% were let go because they lacked the required mechanical skill. Character is not only a matter of good morals, but of willingness to learn, ability to stick to a job until it is mastered, proper attitude towards the employer and other employees, and determination to give value received for the money in the pay envelope.

Amsco Bulletin, American Manganese Steel Div., Vol. 16, No. 3, 1945.

The well-dressed deep sea diver of 1946 may abandon lead on the soles of his shoes in favor of manganese steel. A Michigan contractor received the job of breakwater construction. In his operations lead soles on divers' shoes were being destroyed quickly by sharp rock. So austenitic manganese steel was used and outwore lead many times.

N. J. Zinc Alloy Pot, N. J. Zinc Co., October, 1945.

The Woodstock typewriter contains 2,000 individual parts and requires 20,000 operations to complete. Prior to 1929, iron sand castings were used for the base, top plate and numerous other parts. The complex designs required much painstaking machining and grinding. Since 1929 the maker has used zinc alloy die castings extensively. A 30% saving in production time resulted. For the base the present die has produced 450,000 pieces and is still in excellent condition. Extreme dimensional accuracy is inherent in the die castings. Finishing of the smooth, as-cast surfaces is accomplished by applying a spray black wrinkle enamel, dried by passing the castings through a bank of infra-red lamps for 30 min.

Bulletin, Copper & Brass Research Assn., November, 1945.

Here is the history of the discovery of copper—long before the discovery of atomic warfare—according to Lucretius, the Latin writer. Two powerful tribes were at war. Their bravery and weapons of flint and stone were evenly matched. The leader of the tribe in the valleys had a daring thought to destroy his mountain dweller foes. A great conflagration was kindled and the mountain forest dwellers were forced from their homeland and they sued for peace. When the mountaineers returned to their retreat they found that rocks had melted and run into tiny rivulets that glistened like stars. This material could be easily hammered into various shapes. Thus copper, the everlasting metal, which over the centuries has been smelted, refined and shaped by fire, was discovered by fire.

Silicate P's & Q's, Philadelphia Quartz Co., Twelfth Month, 1945.

"With this issue Silicate P's & Q's completes 25 years of unbroken publication. During the first year (1921) there were only five issues, but thereafter the sheet has appeared regularly on the first of each month."

Martin Star, Glenn L. Martin Co., November, 1945.

"As to the atomic bomb, I feel sure that our resourceful aircraft and electronics in-

(Continued on page 330)

IN THE METAL-WORKING INDUSTRIES

The Magazine Edited for the Men Who Decide:

Which Material

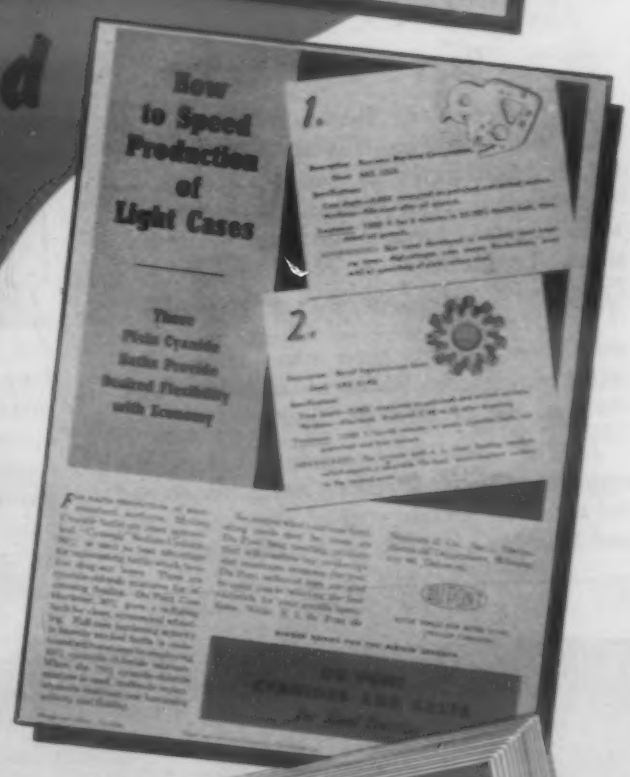
(WHOSE MATERIAL)

Stampings or Machined Parts?

What Method

(WHOSE EQUIPMENT)

Gas Carburizing or Liquid Cyaniding?



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dustries, given proper support and latitude, will find solutions to the new discoveries which currently have a civilized world quaking in its boots. Glenn L. Martin built the first bomber and warned the world that 'the generals who first fight with the flying death will win.' Yet he immediately built the first pursuit plane to knock the bomber down. Later, Martin built the first power turrets to knock down the pursuit plane and then the first self-sealing fuel tanks to withstand bullets of attackers. The battleship looked impregnable, but when Billy Mitchell's bombs dropped from Martin bombers it proved vulnerable."

Electromet Review, Electro Metallurgical Co., November, 1945.

When an Army bomber plunged through two upper floors of the Empire State Bldg. last summer it gave metallurgists a good opportunity to examine the condition of the stainless steel trim on the building's exterior—500 tons of it. A household cleaner was used on a section to remove a black film caused by fire. This exposed again the natural luster of stainless steel, proving that the surface of the metal had not been damaged. The steel had good resistance to the impact of the crash, nor were there any signs of atmospheric corrosion. The building had been completed in 1931.

News of Engineers

Dr. Stephen F. Urban, for nearly 10 years with Carnegie-Illinois Steel Corp. research laboratories in South Chicago, has been made director of research in charge of metallurgical, ceramic and chemical divisions, Titanium Alloy Mfg. Co., Niagara Falls, N. Y. *Dr. Eugene Wainer*, formerly in charge of the chemical and ceramic divisions, research, has been made associate director of research. *William Baldwin* becomes chief of the ceramic division.

John T. Robbins, formerly senior process engineer, Curtiss-Wright Corp., has joined the technical service staff of Peter A. Frasse and Co., Inc., serving as metallurgical consultant, specializing in stainless and corrosion-resistant alloys. He was previously with American Rolling Mill Co. and one time senior metals inspector for the U. S. Treasury.

Ernest Greenway Jarvis, president, Niagara Falls Smelting & Refining, has become acting president of Continental Industries, Inc. and Continental Services, Inc., its managerial affiliate, the action having been taken because of the sudden death of Chester A. Bolles, whose plane crashed in the Hudson River at New York. Mr. Jarvis is a well known figure in industrial and metallurgical fields and belongs to several technical societies.

W. B. Pierce heads the sales development department of Allegheny Ludlum Steel Corp. to assist manufacturers in the solution of problems involving applications of stainless steel and related alloys. Other company connections previously had been Rustless Iron & Steel Corp. and Aluminum Co. of America. He was chief of the stainless steel branch, WPB from January, 1945, and was on numerous wartime committees involving stainless.

E. V. Crane has been made vice president of Sam Tour & Co., engineers, metallurgists and consultants, New York, being in charge of mechanical engineering and metal working projects, including stamping and work hardening problems. For many years he was with E. W. Bliss Co. He is the author of text books and articles on metal working problems, especially pressed metal engineering.

Donald L. Schwartz, formerly superintendent of the metallurgical laboratory of the Cleveland Graphite Bronze Co., has joined Carboloy Co., Inc. as research metallurgist. He did war research at the metallurgical laboratory at the University of Chicago.

Edward C. Hoenicke, formerly assistant general manager, has been appointed general manager of the Eaton Mfg. Co.'s foundry division. He is a nationally recognized authority on permanent mold development, and has been a featured speaker at foundrymen's meetings. He is author of technical papers in American and foreign publications, and is a member of several technical societies.

Clarence H. Sample, formerly of the technical staff of the Bell Telephone Laboratories, has joined Rheem Research Products, Inc. as chief engineer. He will deal with the company's product, "Iridite." He has dealt with protective coatings at Bell since 1930 and is prominent in the work of technical societies.

Otto M. Jensen, executive for many years with Peerless Machine Co., Racine, Wis., has been made works manager and vice president in charge of engineering.

Victor F. Mutch has resigned as president of the Cordo Chemical Corp., Norwalk, Conn., intending to continue in the plastics business, specializing in the manufacture of plastic based coatings.

Fred A. Jackle, works manager, Chase Metal Works & Rolling Mill Plants, has been elected vice president of the Chase Brass & Copper Co. *Walter L. Smith*, manager of the Cleveland plant, succeeds Mr. Jackle.

Chester V. Nass, active for years in technical foundry and metallurgical societies, has been elected vice-president, Pettibone Mulliken Corp. He had joined Pettibone in 1942 after 14 years with Fairbanks, Morse & Co.

Peter V. Armstrong has joined Federal Machine & Welder Co. as chief of the company's new consumer goods division. He was formerly with H. K. Ferguson Co., Cleveland, as a designer, and with Chase Brass Co. as assistant chief engineer at the Euclid-Chase plant.

Henry E. Guerin retired Jan. 1 after 25 years with Douglas Aircraft Co. He invented the process which employs a thick pad of rubber and single low-cost die to form airplane parts under hydraulic pressure. He was born in France.

William J. Priestley has been made vice-president in charge of the Alloys and Metals Division, Union Carbide & Carbon Corp. In 1942 he was chief of the Alloy Steel Div., WPB.

Dr. William T. Griffiths, of London, has been made vice-president and director, International Nickel Co. of Canada. He is chairman of the Mond Nickel Co., Ltd., at which company he has been manager of its development and research department.

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New York Sales Office • 376 LAFAYETTE ST. NEW YORK 3, N.Y.
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Induction Heating Corp. 53
Agency—Walter J. Gallagher

Industrial Steels, Inc. 188
Agency—John Mather Lupton Co.

Inland Steel Co. 78
Agency—Behel & Waldie & Briggs

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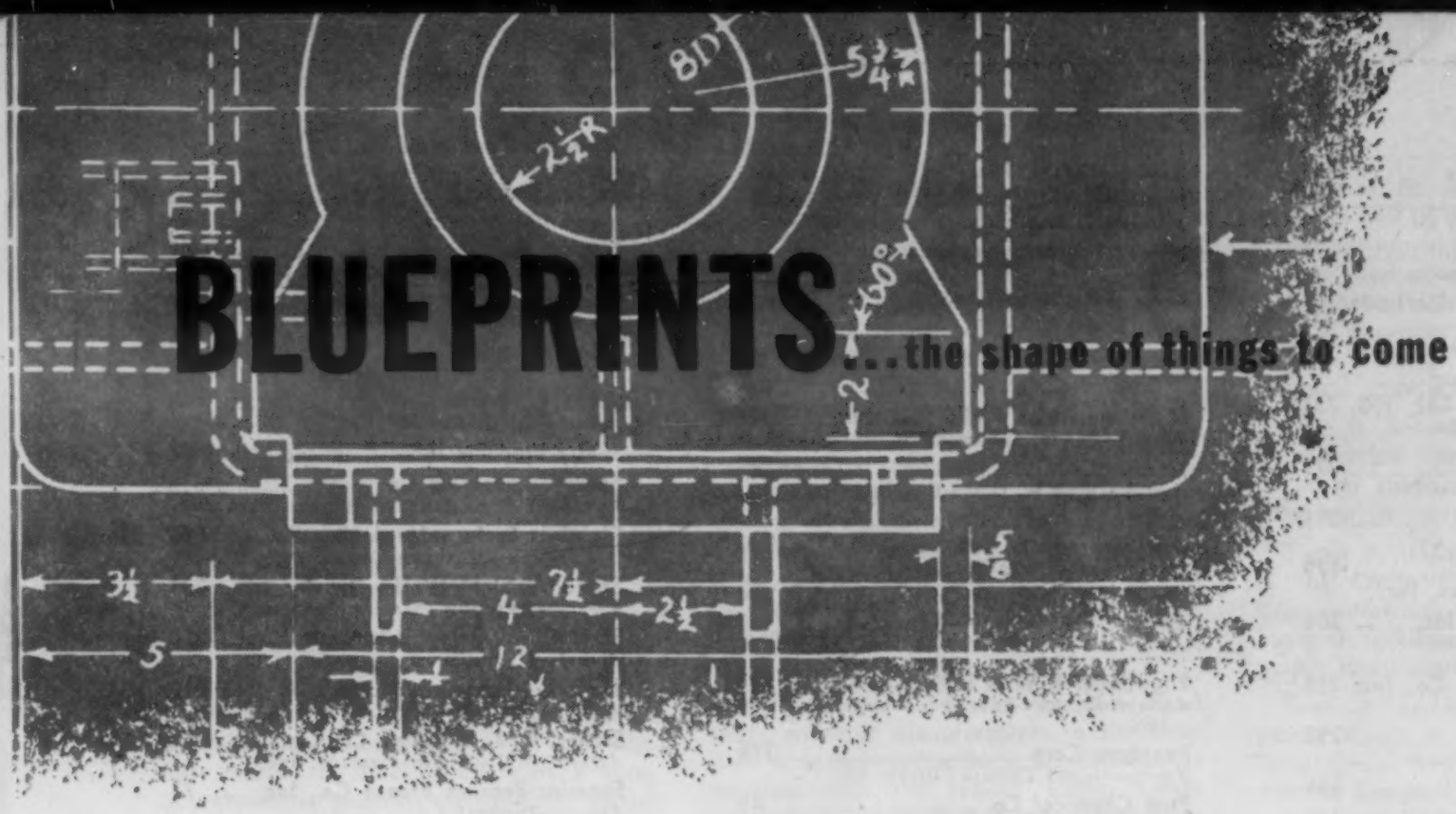

BLUEPRINTS...the shape of things to come

Two Metal Powder Applications

There are two coming developments in metal powder techniques. One is the extruding of tungsten powder into very small tubing for electronic parts. The other involves a process for hard facing of powder parts. Instead of steel powders, which are often difficult to handle, iron powder is used as a base. Then it is given a coating of hard material, Rockwell 72 C, by powder metallurgy methods. Thicknesses of the hard surface can be made to vary from 1/16 in. down to one ten-thousandth of an in.

New Low Expansion Alloy

A new low expansion alloy with a promising field for instrument parts will soon be available for general use. It is a "cobalt invar" (cobalt-chromium-iron alloy) with a coefficient of thermal expansion lower than that of quartz. Parts are cast from melted metal powders and are expected to find application in precision optical instruments for aircraft and industrial uses.

New Kind of Optical Glass

A new kind of glass for optical instruments is in the making which will cause less bending of a beam of light and produce less color-scattering effect. It lets light go through at a faster speed than with usual glass. The key ingredient of this new transparent material would be beryllium fluoride in place of the usual silicon dioxide, or ordinary sand, now employed. The speed of light through glass used in spectacles is 122,000 miles a sec., against 146,000 for beryllium fluoride glass and 186,000 in empty space. The only "fly" in the fluoride is that it is hygroscopic, absorbing water from the atmosphere. This "fly" remains to be exterminated.

Graphite, as Radar Tube Anodes

In view of the prominence of radar and electronics devices in this era, much metallurgical research and development is in this field. It oftens happens that what was used as a substitute material because of the scarcity of the original proves highly satisfactory. Thus, a manufacturer of radar transmitting tubes increased its life more than 30 times by using a different material. The original tube had a tantalum plate. Graphite anodes were used in place of tantalum, which was needed urgently for surgical instruments. The life of the tube was extended from 300 hr. to at least 10,000 hr.

Silicone Rubber from Sand

Silastic parts—gaskets, seals, hose, rubber to metal adhesion, are now commercially available, being of silicone rubber made from sand. It withstands temperatures from minus 70 F to plus 500 F, yet still retaining its original resilience and flexibility. Its good dielectric properties—arc, corona and oxidation resistance—assure durability under hot service conditions. The frequently reinforced with glass fabric.
material must be engineered carefully and

Textiles from Chicken Feathers

One of the leading "gags" of the "Gay Nineties" was that meat packers utilized every part of the hog except the squeal (and they sometimes saved that on phonograph records). Now we learn that chicken feathers can be made into a textile material. They are dissolved to produce a viscous solution, then forced through tiny openings in a spinneret, becoming a highly elastic protein fiber. Plastics can also be made from feathers. They take color easily, and the coarser grades make good insulating wallboard.

Wire Mesh Dies for Printing

Wire mesh fabric—Monel wire cloth is perhaps best—can serve as dies for reproduction of any design or lettering, replacing expensive cuts and dies. They will be doing any ordinary printing, embossing, perforating and pebbling on any sheet material. Artificial watermarks on finished paper and silky or moire backgrounds will be achieved by imposing two masters on the same wire mesh die. Other applications will be over-all designs on checks and bonds, wrapping paper, stationery, cards, cigarette paper and wall paper. The master cut will be impressed on the wire mesh by a simple hand press. These dies will then be easily adapted to ordinary cylinder or flatbed presses.

Heyday for the Handyman

The home handyman will be an all-around skilled artisan with new kits and easy heat appliances for modern bonding, brazing, soldering, even silver-plating. One will soon see a simple plug-in electro plater capable of silver plating that requires no previous experience—but perhaps a little common sense.

Which Refractories Have a Future

The prominence of high temperature alloys during the latter part of the war, what with turbo-superchargers, jet propulsion planes and rockets, has given an impetus to high temperature materials that will carry over into peace. Tracing the tendency back to early in the process, we find refractory bricks. Three kinds of refractory materials hold the most promise for the future due to ability to stand up because of melting points well above 3500 F: Magnesia, alumina and zirconium silicate, or zircon. Especially do the first two have a promising future.

New Type of Dielectric Heating

Trouble is with present methods of dielectric heating, when irregularly-shaped pieces are placed between the electrodes, the areas nearest the electrodes are in danger of being scorched or burned before the entire piece of plywood, plastics, etc. is uniformly heated. But there is in the offing an "electronic blow torch," or dielectric heating unit that hurls ultra-short radar waves at an object to be polymerized, cured or bonded. It will "bring horsepower to microwaves." Before the war the engineers were able to use only a few watts in the microwave section of the spectrum; today they work with kilowatts. Eventually they will be able to project waves effectively from a tube no bigger around than a flashlight. It will be like squirting beams from a nozzle.